WOODLANDS and FORESTRY

Management of Woodland and Woodland Vegetation for Amenity and Recreation with Particular Reference to the New Forest

Donn Small
Forestry Commission

INTRODUCTION

Since the enactment of the Countryside Act 1968, the Forestry Commission's (FC) use of many of its 965,000 ha of forests has been transformed by the provision of a wide range of recreation facilities for visitors. In Great Britain over a wide range of soils, terrain and crops there are in 1982 – 35 camping sites (plus 5 leased sites and 42 youth sites), 876 car parks with 23,700 car spaces, 594 picnic places, 654 walks and trails, 30 visitor centres, 23 arboreta, 6 forest drives for cars, and 166 cabins and holiday homes. Estimates of the total annual visits to its forests are 26 million day visits and 1.7 million camper nights, i.e. for every hectare of plantation there are 27 daily visits and 2 camper nights. In addition there are very many special activities catered for. For example the New Forest alone accommodates riding, cycling, back packing, orienteering, sponsored walks, rides, barbecues, youth activities (including the Duke of Edinburgh's tests), Scouts and Guides, model aircraft, boats and yachts, hunting, and wayfaring for schools.

Nationally, the FC, under its environmental improvement policy has not harvested in the region of some 8,500,000 cu m of maximum yield production, or about £1.8 million/annum in terms of wood revenues not realised, together with an additional direct cost of £800,000/annum on environmental work, so that the total cost can be estimated at £2.6 million/annum (Forestry Commission, 1982).

I am responding to the British Crop Protection Council's invitation to address this Seminar as the Deputy Surveyor of the New Forest, where a considerable experience has been gained on the subject to be discussed.

GENERAL BRIEF WITH REFERENCE TO THE NEW FOREST

Take a fragment of ancient woodland, bond it with commercial oak, beech and fir plantations, intermix with heathland and bogs, graze with ponies and deer,

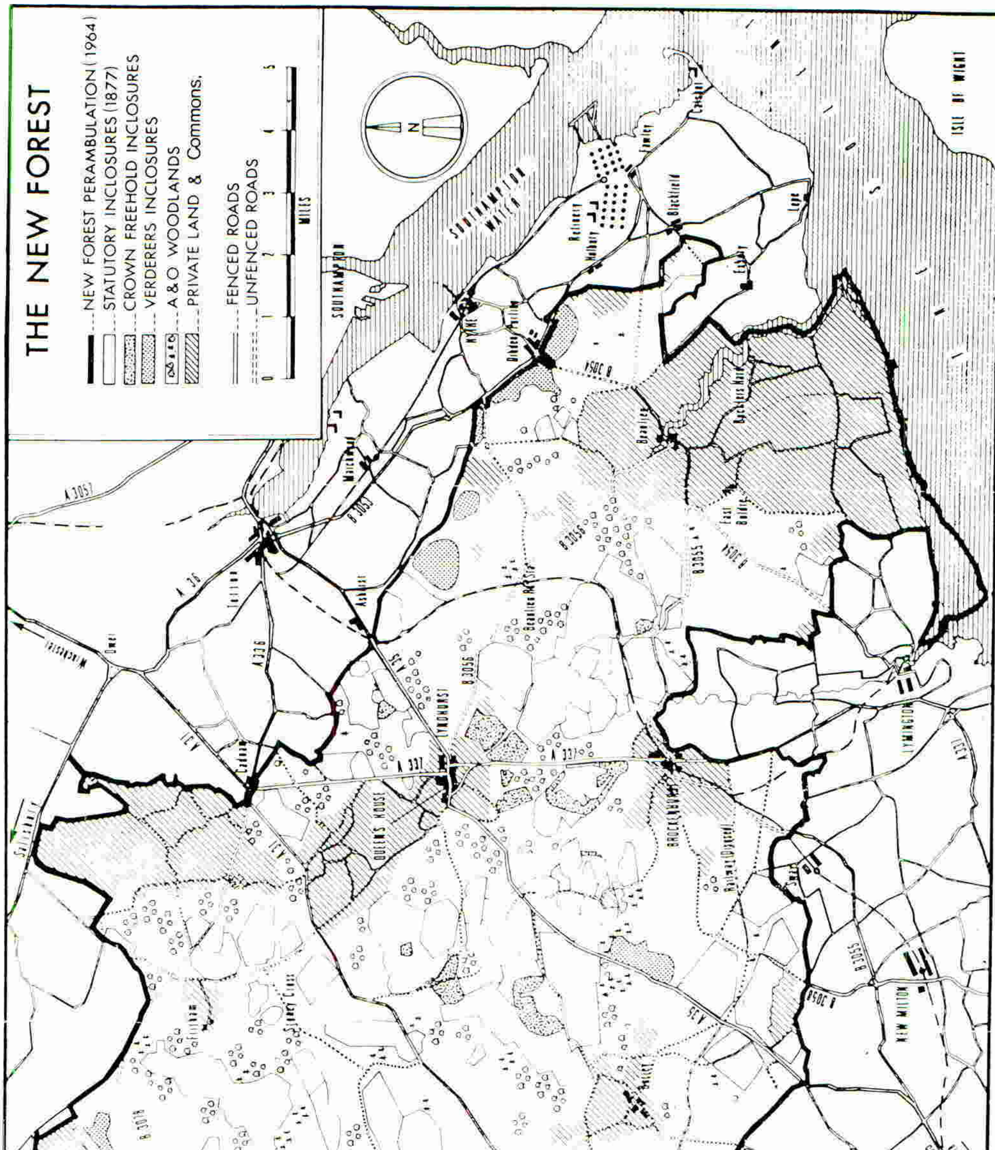
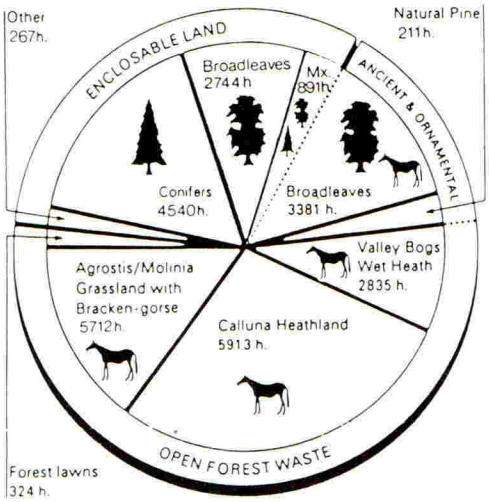


Figure 1. The New Forest.

Distribution of Vegetation within Forestry Commission Areas

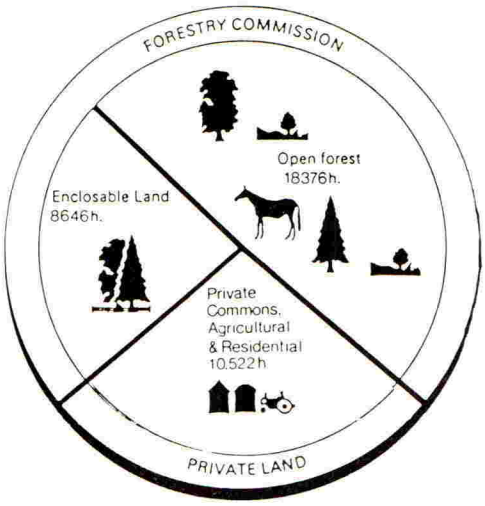


Total Area 27022h. (66773acres)

Figure 2. Distribution of land ownership within the Perambulation.

Distribution of Land Ownership within the Perambulation

Figures show total area in hectares. 1 hectare = 2.47 acres



Total Area 37544 h. (92773 acres)

Figure 3. Distribution of vegetation within Forestry Commission areas.

stir well and blend into an attractive heritage in England – add tents, caravans and motor cars, 6 million annual visitors, add emotion and reaction to taste and you have a recipe for conflict – The New Forest.

The New Forest contains within its ancient boundary – the perambulation (Fig. 1) – 37,675 ha, of which 75% is managed by the FC and 25% is privately owned consisting of farms and residential communities (Fig. 2).

This ancient forest since about 1079 has been the jewel in the crown of southern England and consists (Fig. 3) of a fertile blend of woodland both ancient (3,380 ha) and modern commercial plantations (8,646 ha), interwoven with fertile unenclosed heaths and forest lawns (14,427 ha). It is all owned by the Minister of Agriculture, Fisheries and Food and managed on his behalf by the FC, who together with the ancient but powerful Court of Verderers, established in 1877, now look after the health and welfare of some 5,000–6,000 ponies and cattle belonging to the commoners. Both the Commission and the Court are advised with mutual respect by the Nature Conservancy Council (NCC) (the forest has a status of a National Nature Reserve). The Hampshire County Council and the New Forest District Council play an equally important role in residential planning and highway management.

MANAGEMENT OBJECTIVES

The management of the New Forest as a whole is governed by New Forest Statutes dating from 1877 *et seq.* and by the Minister of Agriculture's Directive, known as the Mandate, from which the management objectives are derived, and which are stated in the 10 year FC Management Plan.

Primary objective for the whole forest

The New Forest must be regarded as a national heritage and priority given to the conservation of its traditional character.

Statutory inclosures

These are fenced areas for protection from grazing, and consist chiefly of timber producing plantations of oak, beech and conifers. The primary management objectives are as follows:

i The broadleaved areas to be managed primarily to perpetuate their visual amenity and conservation values, producing hardwood timber by sound silvicultural systems.

ii The conifer areas to be managed by sound silvicultural systems to produce high quality softwood timber, with, in selected areas, greater emphasis on the recreation and conservation value.

Ancient and ornamental woodlands

These are essentially the remnants of an ancient wood pasturage system, which was heavily exploited in mediaeval times for naval timber, but which today is regenerating outwards, expanding at the expense of the unenclosed heathlands, and is conserved purely for amenity and as a major biological resource. The objectives of management for these remnant areas are as follows:

i These woodlands to be regarded as a component contributing to the national heritage and priority to be given to the conservation of the traditional character.

ii These woodlands to be conserved without regard to timber production objectives.

Open forest wastes

These are the remnants of ancient but continuous heathland kept as such by repeated burning and still being invaded by natural pine and birch, together

with riverside woodland glades known as "forest lawns". This is a complex biological resource heavily grazed in places by ponies and cattle with increasing demands by various factions for either more intensive restoration or more intensive non-intervention. The management objective for this area is as follows:

> The open forest must be safeguarded as a component of the national heritage, and priority given to the conservation of its traditional character with an acceptable balance of the requirements of Commoner's grazing, biological diversity, and stability of surrounding woodlands for peaceful enjoyment by the public.

Recreation

It was in 1971 that major recommendations for the rationalisation of the recreational use of the forest were proposed, and were completed in 1978 by the FC. They were essentially to diversify the locations for car parking and picnicking in suitable locations, and to select areas for camping where infrastructure and ecological considerations made it practical. The objectives are as follows:

i To accommodate the existing public pressures within the forest without fundamentally changing its existing character.
ii To control this pressure with the minimum conflict between the many diverse interests.
iii To provide and maintain a high standard of quality of the facility.

Conservation

The principles of good conservation are practised in all areas of different land use in the forest. These principles are not the easiest to achieve and are governed by the following objectives:

> To maintain the ecological stability and diversity of the forest as a biological bank to afford further opportunities for education and research, recognising that the vegetation types are in constant flux.

WHAT STANDARDS AND METHODS ARE SOUGHT TO SATISFY THE STATED OBJECTIVES

Statutory inclosures

Sound silviculture is practised in all the plantations, taking into account the immense difficulties from the intimate size and age of management units (there are over 4,500 sub-compartments in a total enclosed area of 21,360 acres (8,646 ha), or an average of 5 acres (2.03 ha) each). Continuous regular

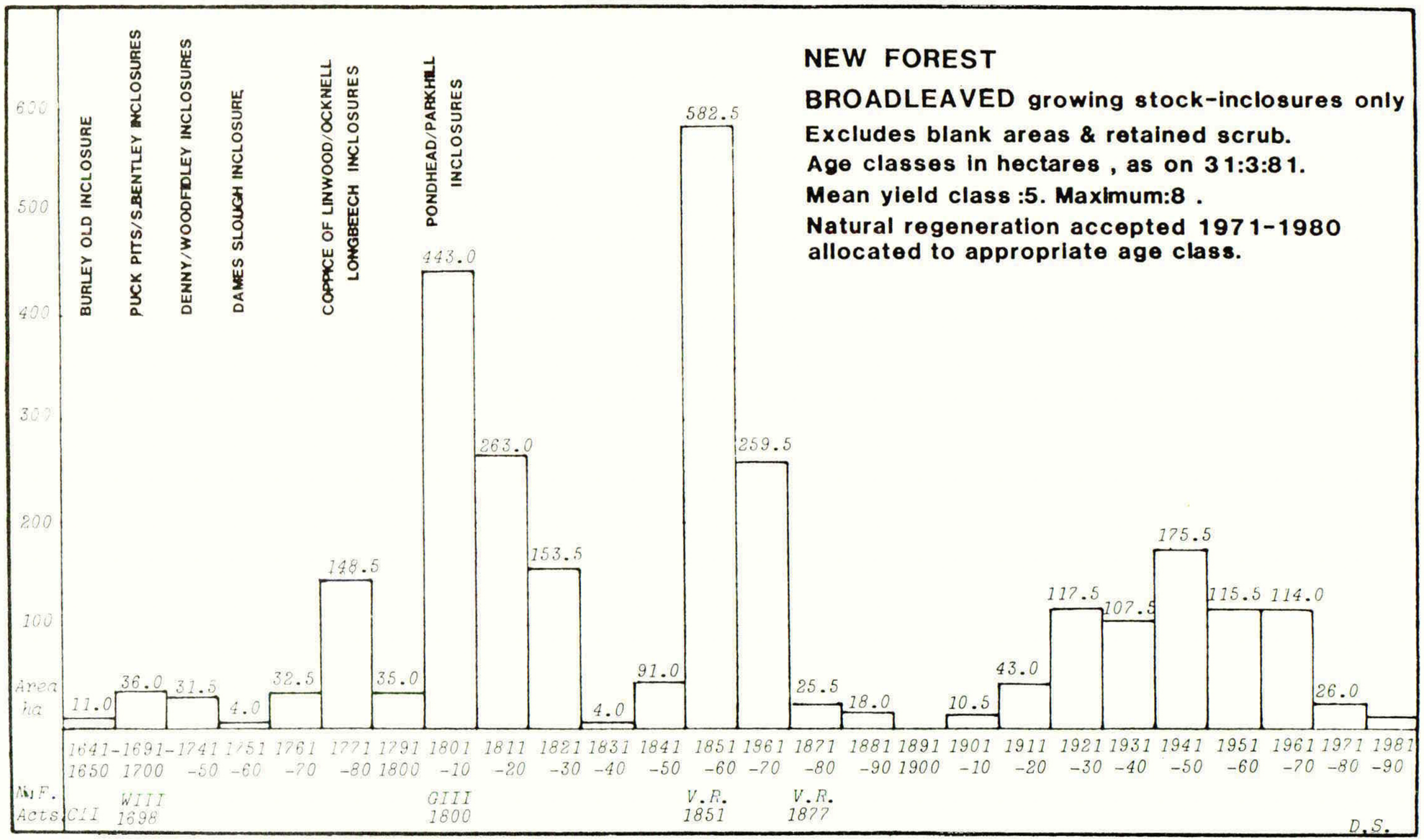
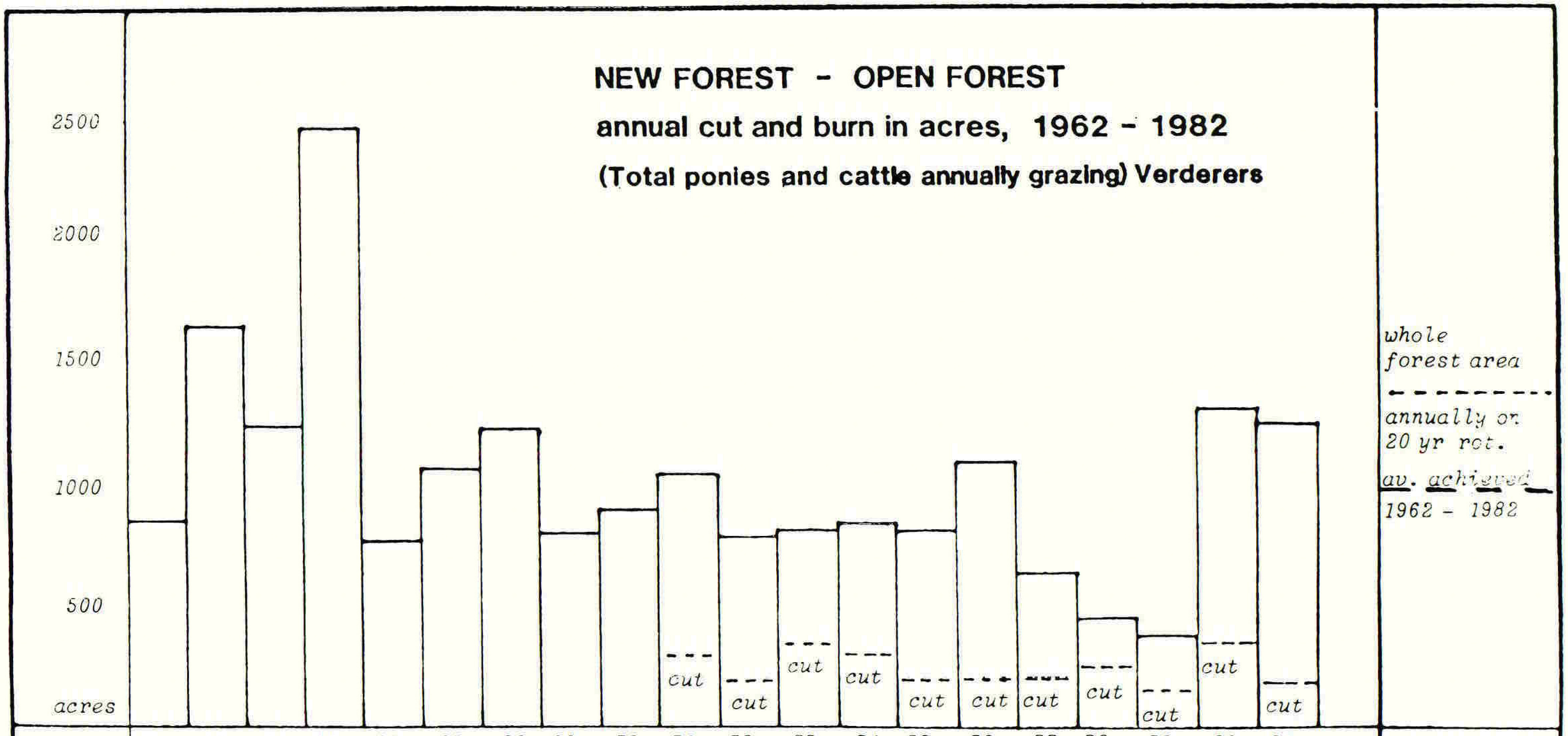


Figure 4. Age classes in ha (decadal from 1641) of broadleaved growing stock in New Forest inclosures as on 31.3.81.

thinning and replanting is carried out with modern power saws and small compact extraction tractors, and mini-forwarders to reduce the ground damage. Timing of activities is scheduled when practical to avoid the bird nesting periods and other conservation interests. Natural regeneration of both broadleaves (Fig. 4) and conifers is accepted and used in conjunction with detailed landscaping advice from our own landscape architects. The rotation for conifers is allocated as 120 years for the amenity working cycle and 50 plus for the economic rotations, with all broadleaves being managed on at least a 200 year rotation. The end result is a very diverse intimate mixture and structure within these inclosures. This we feel fulfils both our amenity and conservation objectives, but is enormously difficult to manage from a forestry production point of view. Access to these inclosures is by gravel tracks, where in many cases the verges are left to produce natural vegetation and only cut when excessive woody growth begins to erode the structure of the road itself. Archaeological and wildlife locations are recorded on our field maps to ensure that managers protect these fragile locations. The population of deer within the forest is controlled by culling by the highly trained team of Forestry Commission keepers to a size that is compatible with an acceptable level of damage.

Ancient and ornamental woodlands

Traditional tidiness has been a major criterion for management of the ancient pasture woodlands, brought about by intensive scavenging of fallen wood for fuel. More recently however revised conservation principles seek to increase the dead and rotting wood habitat by arranging for a percentage of all windblown trees to be left. This is beginning to create a conflict with the heavy fuel wood demand on this fragile resource. The aftermath of the 1976 drought was that over 20,000 dead and dying dangerous beech trees have been removed, but we still retain some 10 to 20 percent dead material on the ground. These woodlands are renewing themselves by natural regeneration, which is extending outwards, and in the period 1876–1972 over 500 ha of new regenerating woodlands has enabled us to practise a policy of minimum intervention. As soon as centres of very old woodland begin to deteriorate it is interesting that, with the heavy grazing intensity, these open gaps soon become enclosed woodland grass glades. Every year trees in these woodlands alongside highways, car parks and camping sites are inspected and if dangerous are removed. In contrast an area in the north was set aside in 1973 as "an inviolate area" where dead trees were allowed to fall and no debris was removed. The reaction from visitors is 'Oh, how untidy'. It may be that urban tidiness versus ecological litter might become a major conflict until there is a better understanding and appreciation of the principles when applied. Ancient rights of pasture and estover are still practised throughout these woodlands. These woodlands still remain today the most scenic resource in the forest and are much loved by painters, photographers and walkers.



YEAR	62 63	63 64	64 65	65 66	66 67	67 68	68 69	69 70	70 71	71 72	72 73	73 74	74 75	75 76	76 77	77 78	78 79	79 80	80 81	81 82	FOREST YEAR 1 APL-31 MAR
total acres	873	1671	1260	2501	796	1090	1237	804	920	1053	799	815	866	840	1116	658	487	368	1335	1291	19 year total 19445 acres
ponies	2035	2005	2181	2327	2462	2536	2727	2906	2814	2742	2982	3187	3154	3503	3589	3595	3748	3466	3430	3071	calendar year (top year)
cattle	2662	2229	2379	1972	2003	2345	1988	1625	1608	1601	1970	2053	3123	3184	2371	1827	1660	1944	2014	1682	
Total	4697	4234	4560	4299	4965	4881	4715	4531	4482	4343	4952	5240	6277	6687	5960	5422	5408	5410	5444	4753	excludes pigs donkeys sheep

Figure 5. Open forest waste – annual acreages cut and burnt. Annual numbers of ponies and cattle grazing. Ha = acres x 0.405.

Open forest waste

This is an enormously difficult part of the forest in which to achieve an equitable balance between traditional use and ecological stability. There is a constant invasion of woody growth into traditional woodland and riverside lawns, a constant evolution towards woodland by birch and pine on the heathland areas all contributing to a dissatisfaction from the Commoners, who witness a grazing resource rapidly changing and degrading. The FC is responsible for the maintenance and clearance of this open forest area to the satisfaction of the Court of Verderers and NCC (Fig. 5). It is often said and written that there is a head-on collision between the objectives of the conservationists and the Commoners. We endeavour to achieve a satisfactory solution by round-table discussions on all the annual programmes of cutting, burning, and drainage improvement on this complex part of the forest. There are naturally built-in legal constraints, such as protection of the bird nesting period and the muir burning statutes which permit burning only between November and March, a period which coincides with the period of highest rainfall. We do not use any chemicals in carrying out this work. There are and will be many many conflicts in the future but the major agency that will maintain the picturesque openess of the forest will remain the animals. Should the viability and economy of commoning change, and there are signs that it is beginning to do so, then the future of these vast open spaces could be at great risk, particularly if commoning disappèars and the graziers are lost for ever.

Recreation

In the period 1971–1978 a major project was completed by the FC to move uncontrolled recreation activities into those areas of the forest jointly considered to be able to accommodate them with minimal damage. 140 car parks, directly associated with the highway network were created from which walking and picnicking were made possible, and 15 campsites constructed where an infrastructure for common services was available. The anticipated and planned capacities were for 5,000 cars parked and 5,000 camping units. Monitoring since 1972 shows that these are the current peak demand levels. The standards of information signing, access surfaces (gravel for low use and tarred for heavy use), building design and internal facilities are in keeping with the natural surroundings and compatible with value for money and efficient low maintenance costs.

Conservation

Man may never know the full implications of his actions on the individual constituent of a conservation system. We endeavour to obtain as complete

knowledge as is currently possible on the life cycle and mechanics of the total system. Solutions arrived at in the New Forest have traditionally been a compromise between complete non-intervention and wholesale change. We have never really satisfied any one of the particular interests, be that naturalists, commoners or visitors. For a forest over which so much alleged study has been made we remain terribly ignorant, and I wonder if today research and study carried out in Universities is not often misdirected. The manager of natural resources is not often asked for his opinion on the aspect of his work for which further research is needed. In the interests of amenity and conservation we have accepted quite severe management constraints in the activities of thinning, felling, burning, cutting heathland, and the period of open forest restoration work which is avoided, for example, during the bird nesting season.

ECONOMICS OF MANAGEMENT SYSTEMS

All our operations in the New Forest are not only governed by Statute but by economic considerations. In financial terms our aim within the inclosures is to obtain the maximum return for the total volume of wood sold. This includes examining the most suitable species to be planted, improvements in fertilising, and protection of young trees with particular reference to broadleaves.

The majority of the forestry work is done by the FC's highly skilled industrial force but where appropriate we sell young crop thinnings standing to forestry contractors. A constant re-appraisal of all our forestry techniques is made to ensure that costs are minimised.

Over-night recreational facilities are operated on a commercial basis, and costs are kept down by the employment of seasonal staff on site and contractual services for all waste products. Overall supervision is by trained permanent forestry staff. I believe in the concept that foresters are not only qualified but are the best people to make contact with our visitors to ensure there is mutual benefit from the experience.

To place a value on the benefits of amenity and conservation should not be difficult. What does conservation cost? One solution is to compare a normal forestry practice of plant – clear-fell at time of maximum volume production, with a system where all the planted crop is retained until dead.

I believe the principles of conservation (i.e. the wise use of a natural resource to achieve stated objectives) can be applied to any timber producing plantation by the simple device of slowing down the changes, but always to harvest the interest on the initial investment. Conservationists have a habit of wisefully applying non-intervention systems with someone else's money! We believe that 10% of the maximum return is an acceptable level for the cost of conservation amenity. The rotation periods must not exceed the physical timber age of the species, e.g. 120 years for conifers and 200 years for oak in the south of England.

PROBLEMS

Any multiple land use management system associated with an ancient heritage is bound to attract adverse comment from those who jealously guard their personal interests. The closer to the resource the critic lives the more intensely he feels. Today's improvements in the media of communications, radio, film, and television, bring issues of the environment into the living room. Unless the resource manager devotes a considerable amount of his time to improve his communications, and has the ability to put forward his professional views in lay terms, and remains flexible to the other point of view – then the conflict will remain inflammable.

Much of today's environmental problems are due to increased mobility, lack of understanding and a strange philosophy that exploitation is fine somewhere else. We attempted in the New Forest to overcome this problem of communication by the establishment in 1971 of a 45 member organisation known as the New Forest Consultative Panel. This meets regularly and my responsibility is to ensure that all issues are well and truly aired and solutions found in areas of conflict.

The constant monitoring of the public use of the forest recreational facilities has shown its value in determining whether any one particular activity is or will create environmental damage, be it noise, visual intrusions or erosion of the resource. The constant care of car parks and campsites, together with forest walks, confirms that the maintenance of high standards is the most vital interface between the visitor and the resource manager. We are still studying the exploratory behaviour of the visitor from our network of car parks. In 1977 Miss C M Graham for her MSc thesis for Wye College, University of London, reaffirmed that the peak arrival time was between 1600 and 1700 hours, most families came out on Sunday, the average day was about 2 hours and the distance walked lasted approximately 30 min. This brief summary does not do justice to this excellent study.

At certain periods in the year, spring or late summer, the weather conditions together with wind create exceedingly dry heathland situations when fire is a constant worry. From records of fire since 1971 a very very low percentage of all incidents were caused by visitors. The remainder originated from highway verges or deliberate action. The change in the recreational pattern and the location of facilities has been a major benefit, as so many people are so well distributed and are constantly on watch. Strategically the forest is well served by a network of forestry gravel tracks and council highways, so access for fire appliances is fast and effective. Constant liaison with the fire service enables us to work closely with them and ensure that access and extinguishing fires is at maximum efficiency.

The herbivore population inclusive of the four species of deer (red, fallow, sika and roe), together with the commoner's cattle and ponies are often considered to be far in excess of the unenclosed forest capacity to support them.

A Select Committee in 1875 stated that of these the cattle were the more efficient and effective graziers for the open forest conditions, and this remains true today. However the true architects of the forest scenery are the ponies, and they are at present under intensive study to ascertain what other methods of management of the open forest might be considered to enable both cattle and pony to survive all the year round. Many ponies have to be removed during the winter at present as they are unable, unlike their ancient predecessors, to survive the rigours of winter.

The owners of these animals, the Commoners, practise today their ancient pasturage system; but they are also being studied as the economy of commoning under today's harsh economic conditions might not survive. The consequent loss of the New Forest pony would be a disaster as within 10 or 20 years the open character of the forest would evolve into woodland. I do not believe even today's foresters would relish such a major change.

This is an important phase in the future of the New Forest for the managers, who await the results of these intensive studies to determine "wither dost thy ancient Nova Foresta go".

REFERENCE

FORESTRY COMMISSION (1982) *Report to ECE/FAO, Agriculture Timber Division.* Geneva: Palais de Nations.

DISCUSSION FOR MR SMALL

Dr T W Wright The National Trust is finding itself increasingly constrained in woodland management by the question of safety for the visitor. What safety factors does the Forestry Commission have to consider in relation to woodland management for recreation.

Mr Small (Speaker) In accordance with our occupier's liability we have to remove dead and dangerous trees every year alongside highways, and in other places open to the public. In the drought year of 1976 we lost 20–30,000 two hundred plus year old beech trees, and these dead trees caused us enormous problems. For eight or nine years now we have had a continuing policy of inspecting trees and felling where necessary. Trees are inspected by my staff every year, and if they are dangerous we fell them without consulting anyone. The question of safety is a responsibility that the manager carries, and that applies to managers of other resources.

Mr Gilmour In amenity woodland areas, do the foresters still select the tallest, straightest, strongest trees when carrying out thinning, and remove the sometimes more interesting or picturesque mis-shapen trees.

Mr Small (Speaker) In the New Forest there are two types of amenity. There is the 'totally-left-alone' amenity where we don't bother with the trees at all, except to take the dangerous

ones out. Then there are the amenity conifer areas, where we do exactly what you say, that is we select to keep the best trees, because, besides amenity, we want some income. The income can come in very useful when the trees reach maturity and are felled, and cash is needed for replanting.

Mr Gilmour In looking after amenity woodland in urban areas one is not interested in commercial returns. In a city area one is concerned in providing pleasant areas for people, and I am quite happy to leave the mis-shapen trees if these are more interesting than the better grown more commercial specimens.

Mr Small (Speaker) What I am saying is that I believe that the healthiest, and straightest and most vigorous trees are also the most interesting ones, and the ones that will serve the amenity requirements the longest.

Sir Ralph Verney (Chairman) Would you like to say something about bracken in the New Forest.

Mr Small (Speaker) The Nature Conservancy Council (NCC) has said that we are not to use herbicides on the New Forest open forest spaces, and we don't. We know that the bracken area is gradually increasing, and I should be delighted to spray it with asulam to control it, but the use of chemicals in the forest is a highly emotive subject. One of the problems is that, because common rights are practised over three quarters of the forest, we would not be allowed to remove animals from the sprayed areas in the precautionary period after spraying. Coupled with this is the reluctance of the NCC to allow the use of herbicides in what is probably the country's best SSSI. But bracken should be removed in order to re-establish the grazing quality of the forest, and there is a real conflict of interest with the NCC over this.

Management of Woodland and Woodland Vegetation for Wildlife Conservation

R. C. Steele
Nature Conservancy Council,

INTRODUCTION

This seminar is concerned with the management of natural and semi-natural vegetation. The bulk of British woodlands is fairly recent plantations; often on ground that has not been forested in historical times, and is composed of non-native species. It is neither natural nor semi-natural and is not considered in this paper although it is of major importance for wildlife and will increase in value with time (see Steele & Balfour, 1979).

Virtually all woodlands in Britain have been modified by man to a greater or lesser extent. Some remain, however, which although not virgin forest are the direct descendants of such forests. They have been managed and may have been planted, but nevertheless retain many of the features of natural woodland and are characterised, as far as we can judge, by many of the species which inhabited them in their virgin state. It is to such woodland that this paper refers. A further term used is "ancient woodland" which refers to woodland that has existed during and continuously since the Middle Ages but may have been managed for centuries. The vast majority of semi-natural and ancient woodland in Britain is composed of broadleaved species but there are important and substantial native Scots pine areas. For the sake of brevity the term broadleaved woodland can be taken to include native pinewoods.

THE IMPORTANCE OF WOODLAND FOR WILDLIFE CONSERVATION

Woodlands once covered much of the land of Britain and indeed, were it not for man, would again develop extensively. It is not surprising therefore that many of our plants and animals are well adapted to woodland (Steele, 1971).

Some 236 species of vascular plant, excluding trees and the taller shrubs, occur extensively or mainly in woodland, or have a wider ecological range but often occur in woodland. Most of these probably need the shelter provided by

woodlands but for some there is a more definite saprophytic, parasitic and semi-parasitic association with woody species or litter, and many fungi form mycorrhizal associations.

Few species, or groups of species, of woodland plants belong to a particular woodland type or are characterised by specific tree dominants. The main exception to this are the group of northern pinewood plants. Other interesting elements of Britain's native woodland flora are the endemic *Sorbus* species found mainly in the west and north, and the oceanic (or Atlantic) plants. There are eight markedly oceanic vascular woodland species of which six are ferns, there is also a substantial oceanic moss and liverwort component which forms a phytogeographical element of which Great Britain and Ireland are the European centre. The lichen flora too contains a rich oceanic element.

Many mammals are associated with woodlands although few occur exclusively in them. Perhaps the animal most tied to woodlands is the Red squirrel (*Sciurus vulgaris*). All species of deer live in woodland or make use of them, as do the carnivorous and omnivorous land mammals and many rodents and insectivores. Most species of bat hunt over, or in, woods; many species nest in hollow trees, especially in summer and some may hibernate in such trees.

A large number, about 110, of the breeding species of birds in this country have some association with woodland, with trees, or with scrub. Of these about one third are invariably associated in the breeding season, and a further two dozen are mainly associated with these habitats. The passerines are especially well represented and of the British breeding birds of prey only two, the Peregrine falcon (*Falco peregrinus*) and Marsh harrier (*Circus aeruginosus*) have no association with trees. As with woodland plants, perhaps the best defined group of birds is that associated with the pinewoods of the central Highlands of Scotland. Of the rare woodland birds the Red kite (*Milvus milvus*) is a true relict now confined to limited areas of central Wales. Other species, such as the Osprey (*Pandion haliaetus*) and Wryneck (*Jynx torquilla*), are rare because they are at the fringes of their distribution.

A huge variety of invertebrate animals live in woodland (Steele & Welch, 1973). For example, probably more than half the British species of lepidoptera are to be found in native woodland, and the trees themselves support a large proportion of these. More than 100 species feed on oak (*Quercus* spp.), sallow (*Salix* spp.), birch (*Betula* spp.), and hawthorn (*Crataegus* spp.). Generally speaking the lepidoptera of broadleaved woodlands are very much more numerous than, and distinct from, those of conifer woodland, and the richness of the lepidopterous fauna of a woodland depends on its structural and floristic diversity.

Dying and dead wood is a major resource for animal species and Elton (1966) has estimated that if fallen timber and decaying trees are removed from a forest the whole system is impoverished by perhaps one-fifth of its fauna. Nearly 1,000 species of animals, of which a large proportion are insects,

are known to be associated with dead and dying trees.

EXTENT AND DISTRIBUTION OF NATURAL AND SEMI-NATURAL WOODLAND

The extent and distribution of natural and semi-natural woodland has been assessed by Steele & Peterken (1982). Of the 2,000 kha of woodland in Britain, some 660 kha are estimated to be broadleaved woodland. The 660 kha can be divided into: 367 kha high forest; 27 kha coppice; 266 kha unproductive, scrub and felled.

Distribution and ownership of the 394 kha of productive broadleaved woodland (high forest and coppice combined) is shown in Table 1.

Table 1
Distribution and ownership of productive broadleaved woodland in 1979 (kha) between Forestry Commission (FC) & private

	High forest		Coppice		Total	
	FC	private	FC	private	FC	private
England	39	256	1	26	40	282
Wales	6	27	-	-	6	27
Scotland	4	35	-	-	4	35
Great Britain	49	318	1	26	50	344
	367		27		394	

The distribution of the major woodland classes, both natural and planted, in upland and lowland Britain is shown in Table 2.

Table 2
Distribution of major woodland classes in upland and lowland Britain, 1965 (kha)

Woodland class	Lowland	Upland	Total
Conifer high forest	207.0	710.7	917.7
Broadleaf high forest	245.9	104.1	350.0
Coppice	27.3	2.3	29.6
Scrub and felled	198.9	246.9	445.8
Total	679.1	1064.0	1743.1

The distribution of broadleaved species is shown in Table 3.

Table 3
Extent of various broadleaved species in 1947 (ha)

	England	Wales	Scotland	Great Britain
Oak	250 528	34 079	30 649	315 256
Ash	46 511	6 226	3 174	55 911
Beech	49 749	3 230	20 915	73 894
Birch	62 434	8 937	87 785	159 156
Chestnut	15 822	67	11	15 900
Sycamore	23 860	2 566	4 262	30 688
Alder	4 060	2 839	3 030	9 929
Hornbeam	6 192	13	5	6 210
Poplar	1 234	47	-	1 281
Lime	553	26	-	579
Elm	7 672	403	2 783	10 858
Willow	2 011	276	204	2 491
Norway maple	82	3	-	85
Cherry	42	3	-	45
Hazel	24 562	2 567	1 319	28 448
Other	14 278	602	590	15 470
Total	509 590	61 884	154 727	726 201

The age-class distribution of broadleaved high forest is shown in Table 4.

Table 4
High forest by age-class (kha) in 1970

Country	Age-class								Total
	Pre-1901	1901 1910	1911 1920	1921 1930	1931 1940	1941 1950	1951 1960	1961 1970	
England	179.4	23.0	14.0	12.6	13.6	13.3	21.8	0.8	278.5
Scotland	29.4	2.4	1.2	1.5	1.3	1.6	1.7	0.2	39.3
Wales	16.0	2.5	0.8	0.9	0.8	0.9	3.1	0.5	25.5
Total	224.8	27.9	16.0	15.0	15.7	15.8	26.6	1.5	343.3

NB 1. Sources for the information contained in Tables 1–4 are given in Steele & Peterken (1982).
2. The totals in the Tables do not always agree with each other because the information given in the Tables relates to different dates as shown.

From these Tables it can be seen that broadleaved woodland in Britain has the following characteristics:

i Broadleaved woodland is overwhelmingly biased to private woodland in England.

ii It is strongly associated with the lowlands and lowland fringes.

iii In relation to species:

a. most species are strongly biased to England the exceptions being birch and to a lesser extent beech, elm and alder;

b. oak predominates in England and Wales but birch predominates in Scotland;

c. that over 90% of all broadleaved woods are dominated by five species, namely oak, birch, beech, ash and sycamore.

iv The age structure of broadleaved woods is biased to 19th century age-classes most of which are now beyond normal timber rotations.

CONSERVATION ASSESSMENT OF BROADLEAVED WOODLANDS

The criteria used in assessing the nature conservation value of woodlands are described generally in Ratcliffe (1977) and are elaborated in Peterken (1981). These are:

Size
(extent). In general the larger the woodland the more important it is for nature conservation especially if it is an isolated habitat island.

Diversity
Sites with a range of woodland types are valued more highly than those with one or a few types, and sites with more species are better than those with a few. Variety is preferred to uniformity but this depends of course on comparisons between similar types of woodland.

Naturalness
Woodlands which have been least modified in structure and composition by man are most valuable.

Rarity
Rare species or communities increase the conservation value of a woodland.

Fragility
Fragility can relate to internal factors e.g. successional change or the vulnerability of small populations, or to external factors e.g. human action; or a combination of the two. Fragile ecosystems and species have high value.

Typicalness
Good examples of common woodland types are as valuable as examples of rarer types.

Recorded history
Woods which have a well recorded history have great value especially in relation to scientific studies.

Position in an ecological/geographical unit
A wood which is contiguous with other types of semi-natural habitat gains in value.
Potential value
It may be possible to increase the conservation interest of a woodland where this has been diminished as a result of management.
Intrinsic value
Certain species, e.g. birds and conspicuous flowers appeal strongly to a great number of people and hence raise the value of a woodland in which they occur.

These criteria are valued differently by different nature conservation interests. Research may place a high value on typicalness and recorded history but the intrinsic appeal of a woodland may be most important for botanists and bird-watchers. The criteria mostly re-inforce each other but there are some potential conflicts e.g. between diversity and naturalness. Some criteria e.g. diversity can be objectively assessed while others, e.g. intrinsic appeal are largely subjective. Nevertheless, on the basis of these criteria and surveys of woodland some 60 kha of woodland are listed in *A Nature Conservation Review* (NCR) (Ratcliffe, 1977) as of such high value that they ought to be managed primarily for nature conservation. A further 60–70 kha are included as Sites of Special Scientific Interest (SSSI).

High value for nature conservation is very highly correlated with ancient semi-natural woodlands and most NCR and SSSI woodlands fall into this class. Peterken (1981) has estimated that there are some 300 kha of ancient semi-natural woodland which contain most of the NCR sites and SSSI, the future management of which is most important for woodland wildlife and its conservation.

PAST METHODS OF MANAGEMENT OF SEMI-NATURAL WOODLANDS

Rackham (1976) has provided us with a clear account of how semi-natural woodlands were managed in the past. He describes how by the thirteenth century, the place of woodland in the English countryside was well established. Woods whose primary function was to produce underwood and timber were differentiated, as they were earlier, from the various categories of wood pasture. They were properties with definite boundaries and were permanent features of the landscape.

The management of such woodland was both intensive and conservative. Woods were managed on the basis that if a tree was felled another would grow in its place. Surveys of that period either state a coppicing rotation for woods or give a figure for the expected annual return. Felling at fairly short intervals ensured vigorous re-growth and woods were fenced to keep out stock which might eat the young shoots.

Most of the woodlands were of the type we call coppice-with-standards. The woodland was made up of standard trees and underwood; the former produced timber at irregular intervals, the latter produced an annual return of wood. Wood was often the more important and features most persistently in the records.

The underwood or coppice was cut at short intervals, five to seven years was common, and the annual acreage fluctuated, probably depending on markets. The species mixture was much as occurs now in ancient woods namely ash, oak, hazel, maple, elm, lime, birch and crab-apple. The commonest recorded uses are firewood and fencing but building materials were also important.

The major use for timber from the standard trees was in building and oak appears to have been much the commonest timber tree. Trees of all sizes were harvested and regeneration does not seem to have been a problem.

GENERAL PRINCIPLES FOR THE MANAGEMENT OF SEMI-NATURAL WOODLAND

Coppice and coppice-with-standards, formerly much the most common form of management for our semi-natural broadleaf woodlands, are practiced now only on a very restricted scale as is evident from Table 2. The reasons for this are varied and include the need to build up Britain's reserves of wood, the higher yield of wood and money obtained from non-native conifers, problems with pests such as deer and the Grey squirrel, the much shorter time scale for a return on investment produced by conifers and so on. Whatever the reasons the present management of broadleaved woodland, and this with the addition of some 10 kha of native pinewood make up our semi-natural woodland, is unsatisfactory.

In seeking to develop more satisfactory management practices the following points need to be made:

i Utilisable timber should be produced in the majority of broadleaved woodland.

ii That nature conservation objectives should be prominent in old ancient, semi-natural woodlands and predominant in some.

iii That broadleaved woods should be treated by a variety of systems and long-established silvicultural practices should be maintained in those sites most important for nature conservation.

iv That in the management of broadleaved woodlands, preference be given as far as possible to native broadleaved species.

Peterken (1977) has described fifteen principles to be considered in determining the treatment for any area of broadleaved woodland. These can be broadly summarised as follows:

i Existing structures and treatments should be changed as little as possible. Thus high forest and coppice woods should so remain.

ii Traditional treatments should be retained or restored especially in the most important woods for conservation. Thus it is highly desirable to coppice much of the ancient, semi-natural woodlands.
iii A proportion of woods should be left untreated and interfered with as little as possible.
iv The more important a woodland is for nature conservation the more restrictive are the conditions that will be placed on wood production.

ECONOMIC CONSIDERATIONS

The cost of different silviculture and management options is clearly also a major factor in helping to determine what course of action to pursue. The dearth of good data led the Nature Conservancy Council to commission two research projects (Lorrain-Smith (1982) and Pryor (1982)) requiring economic analyses of a variety of woodland.

The woodland types studied were:

i Acid western oakwood
ii Oak-Ash woodland
iii Oak standards over hazel coppice
iv Beech woodland
v Sweet chestnut coppice
vi Coppice-with-standards
vii Highland birch woods.

The projects have just been completed and require detailed study but first impressions can be summarised as:

a. the value of the timber in many of the examples was surprisingly high;
b. the treatments applied to these standing crops have a far greater overall effect on profitability than the Land Expectation Value of successive crops;
c. at lower interest rates some hardwood options compare favourably with conifers at high price and productivity levels; however at lower levels of price and productivity and higher interest rates, conifers are almost always far more profitable;
d. the uncertainty associated with hardwood crops is considerably higher than with conifers because of the relatively much greater range in productivity and timber prices;
e. ash and cherry appear to be particularly profitable hardwood species;
f. some of the more unusual options, such as underplanting, appear to be much more profitable than is often suggested.
g. sweet chestnut coppice can be more profitable than Corsican pine under poor conditions and high discount rates but less profitable under good conditions and lower discount rates;

h. coppice options appear favourable in adverse conditions or with high discount rates but conifers were normally more profitable;
i. few birch options appear financially desirable even after the birch has been established.

In general, the possible variation in the large number of variables present in such situations makes it very difficult to generalise or to make accurate predictions of profitability.

MANAGEMENT TREATMENTS

On the basis of the foregoing considerations it has been proposed (Steele & Peterken, 1982) that four broad treatment types for broadleaved woodland should be recognised:

i Minimum intervention
ii Coppice including coppice-with-standards
iii Restricted high forest
iv Unrestricted high forest.

A brief description of the area and proposed treatments for each of these types is given below.

Treatment class I. Minimum intervention (22 kha)

The 22 kha proposed for this treatment is made up of 20 kha of unproductive, ancient, semi-natural woods and 2 kha of similar but recent woods. The aim for the woodlands is to maintain or restore near-natural woodland in both composition and structure, and to minimize human activity in them although some activity, e.g. controlling invasion by other trees or the intensity of grazing, may be necessary. Such woods would be important scientifically, by providing 'controls' against which the effects of different management practices could be assessed. Whenever possible such woods should have the status of nature reserves.

Non-intervention as a type of treatment can only be justified in the longer term on a limited number of sites although in the short term it would be expedient to apply it more widely whilst alternative treatments are being decided.

Treatment class II. Coppice (167 kha)

The proposal is to maintain 27 kha of exiting coppice and restore coppice treatment to 140 kha of largely unproductive, ancient, semi-natural woods. The preferred treatment would be coppice-with-standards. The standards should be oaks or other trees native to the site. Natural saplings would be

preferred, but planting would be acceptable in the majority of sites. Coppice would be cut on a rotation that would vary in relation to markets. Planting of coppice species not native to the site is undesirable: gaps should be filled by layering or natural regeneration, or, if planting is necessary, using species growing in the immediate vicinity.

Such woods would produce good quality oak and other timbers and a steady supply of firewood, pulpwood and specialist materials for crafts and turnery.

Treatment class III. Restricted high forest (197 kha)

After the minimum intervention and coppice types these are the most important stands for nature conservation. The principal restriction would be to use species native to the site which in most cases means the species which grow there now. Preference would be given to other than even-aged systems of high forest, e.g. to selection forest, two-storied high forest and high forest with standards. If even-aged systems are necessary, group, strip and wedge systems of felling and regeneration would be preferred. Alternatively clearfelling could be undertaken in very small groups. Rotations should be long, or the high forest with standards system adopted, in order to provide mature timber habitats. Natural regeneration would be preferred to sowing or planting but if this is impracticable, planting should be at wide spacing and any natural regeneration should be incorporated into the crop. Conifer nurses should not be used. Thinning should be as early and as heavy as is practicable and a mixed canopy should be retained as far as possible at least until the final thinning. This category is clearly very varied and requires much more detailed consideration.

Treatment class IV. Unrestricted high forest (274 kha)

A conservation case can be made for treating these stands as 'restricted high forest' but this is not easy to justify against the competing demand for intensive timber production. This treatment type contains those broadleaved woods in which more intensive forestry and a wider choice of broadleaved species is acceptable.

CONCLUSION

The proposals contained in this paper are based on those presented to the "Broadleaves in Britain" symposium, sponsored jointly by the Forestry Commission and the Institute of Chartered Foresters held in Loughborough in July 1982. They are also close to those made by the House of Lords Select Committee on Science and Technology in the Sherfield Report (1980).

Among other points the Committee recognised the importance of ancient woodland, proposed that a special category of "nature reserves" be established based on them, recommended that other broadleaved woods should be managed as productive sources of hardwood timber, and proposed certain developments in research, marketing, financial aspects and the role of the Forestry Commission (FC) to facilitate this.

The main feature of the proposals put forward here is that the sacrifice of potential timber production necessary for wildlife conservation should be concentrated in those woods of special interest, that is, mostly ancient semi-natural woodland which cover an estimated 300 kha. The management of these woodlands will depend upon three important aspects:

1. The development of appropriate silvicultural methods and treatments. There has been a welcome upsurge of interest and work recently, and the FC and others are taking important initiatives (see Malcolm *et al.* 1982).
2. The control of pests. The Grey squirrel is a major impediment in many parts of the country to broadleaved silviculture.
3. The development of appropriate financial incentives to the private growers who own most of the broadleaved woodland. There is a higher rate of grant for planting broadleaves and native Scots Pine but management grants, Capital Transfer Tax, and taxation relief are other important factors.

REFERENCES

ELTON, C.S. (1966) *The pattern of animal communities.* London: Methuen.

LORRAIN-SMITH, R. (1982) Silviculture options in broadleaf woodland. *Contract Research Report to NCC.* London: NCC.

MALCOLM, D.C.; EVANS, J; EDWARDS, P.N. (1982) (Eds) *Broadleaves in Britain.* Edinburgh: Edinburgh University Press.

PETERKEN, G.F. (1977) General management principles for nature conservation in British woodlands. *Forestry* 50, 27–48.

PETERKEN, G.F. (1981) *Woodland conservation and management.* London: Chapman and Hall.

PRYOR, S.N. (1982) An economic analysis of silvicultural options for broadleaved woodland. *Contract Research Report to NCC.* London: NCC.

RACKHAM, O. (1976) *Trees and woodlands in the British landscape.* London: Dent.

RACKHAM, O. (1980) *Ancient woodland.* London: Arnold.

RATCLIFFE, D. A. (Ed) (1977) *A nature conservation review.* Cambridge: Cambridge University Press.

SHERFIELD, Lord, (1980) House of Lords Select Committee on Science and Technology (Sess. 1979/80). Second Report. *Scientific aspects of Forestry.* London: HMSO.

STEELE, R.C. (1971) The value for conservation of traditional broadleaf and conifer woodland. *Supplement to Forestry, 30–35.* Oxford: Oxford University Press.

STEELE, R.C. (1972) Wildlife conservation in woodlands. *Forestry Commission Booklet No. 29.* London: HMSO.

STEELE, R.C.; BALFOUR, J. (1979) Nature conservation in upland forestry – objectives and strategy. In: *Forestry and farming in upland Britain* 161–192. Edinburgh: Forestry Commission.

STEELE, R.C.; PETERKEN, G.F. (1982) Management objectives for broadleaved woodland – conservation. In: Malcolm, D.C. *et al.* (Eds) *Broadleaves in Britain* 91–103. Edinburgh: Edinburgh University Press.

STEELE, R.C.; WELCH, R.C. (Eds) (1973) *Monks Wood: A nature reserve record.* Cambridge: Institute of Terrestrial Ecology.

DISCUSSION FOR MR STEELE

Mr Small 80% or so of the UK broadleaved high forest is even aged, and this is liked by the public and by conservationists. But many of the oak woods have reached maturity and are getting near their terminal age. How would the Nature Conservancy Council (NCC) want to regenerate these stands for future conservation purposes?

Mr Steele (Speaker) We want smaller felling areas rather than the large clear fells often used for conifers. Its really scale with which we are concerned. We recognise that to regenerate those forests that are subject to an active management policy there will be a need to accept some flexibility in management, in order to get a proper age class distribution.

Mrs Wright Is there a potential for use of exotic broadleaved species in the schemes that you are promoting? Some introduced species do have conservation interest; for instance *Nothofagus* has been found to support quite a variety of insects.

Mr Steele (Speaker) The difficulty with most native species of trees is that they tend to be outperformed, both economically and in volume production, by non-native species. In many of our woodlands there has to be a use of some economic non-native species, such as poplars and *Nothofagus* for economic reasons. We need a graded management series from strict nature reserves with good representation of the natural development of native species, through managed woodlands of native species and woodlands of exotic broadleaves, to exotic conifer plantations.

Dr Wright The private forest and woodland owner is very grateful to the NCC for demonstrating how nature conservation can be fully compatible with productivity, and with economic returns, from woods that are not of the highest ecological importance. This is really getting through to the private owner, and is likely to lead to a very good response in the form of management and regeneration of broadleaved woodlands.

Sir Ralph Verney (Chairman) Are we right to accept the Forestry Commission's (FC) new plastic tree shelters without further experiment?

Mr Steele (Speaker) It is an experiment, which is initially very promising, but we need to develop it further. There is no doubt that if young trees can be protected at an early stage from rabbits and small mammals, growth rates can be quite excellent. What the FC is doing by sheltering the young trees is producing growth rates that will get them away quite quickly.

Mr Burdekin The technique is catching on quite widely, even before we (the FC) have been able to get a long term view of it ourselves, and we may yet find some snags. But we are pleased with the interest that is being shown.

On a rather different topic, we have at this meeting, been discussing mainly problems on land owned by public bodies or big institutions with substantial funds behind them. But with woodland, the emphasis is more likely to be with the private owner. What do we know about the interests and motives of the many thousands of private owners, mostly of small woods of say five – ten acres or so? Ought we to know more about them if we are going to try to convince them of the measures that we think they ought to take?

Mr Steele (Speaker) I don't think that we do know, but it is likely that they have a range of interests. My main concern is that most of these owners feel that they should be doing something much more actively with their woods. In many cases they will be quite pleased to learn that their low level of management is beneficial for wildlife.

What I am advocating is a system of forestry that may not bring in a large return, but which will not involve a substantial investment; I hope it will produce some good timber and some cash, as well as creating a valuable wildlife habitat. This is a way of making a better use of these woods, which at the same time is not incompatible with other countryside pursuits, and particularly the sporting interest.

Sir Ralph Verney (Chairman) It is worth mentioning the study in South Wales on small woodlands, and also the one being mounted in Norfolk, to find out why farmers have these little woods, and what they want with them.

Mr Shaw Interesting questions have been raised about how to promote the effective management of deciduous woodland, although the examples have been mainly at a fairly large scale. This issue is also fundamental to the conservation of small woods and copses, and I should like to explain the response in Norfolk to this need. In Norfolk, the major problem lies in the deteriorating quality of a large number of small fragmented areas of woodland. A recent survey by the County Planning Department has demonstrated that 80% of all small woods are unmanaged. The challenge is to stimulate their management.

Studies have suggested that there is a market for timber if a threshold can be achieved to justify the felling of woodland, and subsequently of replanting. The main obstacle to this is an organisational one. Under the auspices of the Norfolk FWAG, the County Council and the Countryside Commission have therefore funded the appointment of a Small Woods adviser, whose job is to act as a broker between individual landowners and the timber trade in East Anglia. The aim is two-fold: first, to demonstrate to farmers that there is a return on a timber 'crop' from copses, and secondly, to ensure the continued future of the small woodland as a major landscape feature in an otherwise intensively farmed countryside.

UPLANDS

The Management of Upland Vegetation for Amenity and Recreation

I. D. Mercer
Dartmoor National Park Authority

THE UPLANDS

It is necessary first to deal in definitions and these must be affected by the other titles that are being used at this Conference. The programme suggests to me that I must deal with herbaceous and low shrub vegetation above the 'limit' of cultivation. I must try also not to get involved in the discussion of that limit, for it is a fascinating topic and there is plenty of evidence that it has oscillated enormously through the last three thousand years. At the beginning of that time Neolithic and then Bronze Age men effectively inserted between blanket bog and forest in the south, and in the more mountainous regions between alpine communities and the forest, what for these purposes we might call moorland and upland heath. For our purpose also we must include the blanket bog and the alpine communities in the total concept of upland vegetation. Thus the whole might include up to nine or ten vegetation associations though the separation of all of them may not be useful in a management context.

Blanket bog, valley bog and mire will make up one important group. Heath and *Vaccinium* moorland another. Then we should recognise a great group of grasslands which one must accept grade with each other, and grade into heath and bog. *Agrostis/Fescue* grassland may be modified by the density of gorse present or by invasion by bracken, *Molinia/Calluna* moorland will grade into blanket bog or valley bog and grass heaths (without *Molinia*) will be an intergrade between many other associations.

One must superimpose the status of the land upon the vegetation classifications, which are mappable to certain scales. In a model upland there will be a central core that is unenclosed and this may or may not be common land in a legal sense. It will be surrounded normally by large enclosures of the same vegetation usually occupied by a single manager which may be called ffridd in Wales, or newtakes in Dartmoor, for instance. (You will expect me to refer to Dartmoor most of the time.) In the model, outside these large enclosures and below them altitudinally will be the field pattern of the local landscape.

This will normally be of improved grassland and even arable, right up to the moorland enclosure boundary but may of course also have reverted under recent lack of management to hold a similar set of vegetation associations to that above the cultivable limit.

AMENITY AND RECREATION

It is necessary then to look at the amenity and recreation needs which are implicit in the title. The elite of the early middle ages recognised the recreation value of upland, and chases and forests were developed in such landscapes. They also quite quickly recognised the need to have resident managers, of whatever lowly origin, to ensure that the chase remained open; so some settlement within the forest was allowed from the earliest times, but a hunting regime was imposed upon it. This situation seems to have held until the late 18th century when the Wordsworths of this world suddenly awoke, in other than huntsmen, the recognition of 'scenery' and the magic of the upland for those energetic enough to get to it. Wordsworth said that "every man with an eye to perceive and a heart to enjoy should have access to the hills". Thus have amenity and recreation, whatever your definitions of the words, been linked, from the beginning of modern appreciation of upland and its vegetation. One must accept that for this country the campaign which Wordsworth began in the late 18th century came to a head in 1949 with the National Parks and Access to the Countryside Act. In the next few years we designated 10 national parks all of which have upland and its vegetation as their core, though admittedly the Pembrokeshire Coast looks as though someone peeled the rind from round the core and left it hanging to the south. There is no doubt that while natural beauty is a phrase used in 1949 the pressure that brought about that Act of Parliament was a pressure concerned with access and thus with mild forms of recreation.

There is within that Act a list of the kinds of landscape on which local authorities and others might make access agreements and orders, and that list includes 'moor and heath'. The generic term applied to the list in the Act is 'open country' and that is a pointer to the qualities which the recreator is seeking as characteristics of the vegetation, for his purpose. Just as scientists apply their own specialist meanings to ordinary English words, so legislators, and inevitably therefore those who argue about legislation, begin to apply specialist meanings to phrases like 'open country' which since 1968 has included woodland for instance! Neither botanists in the mass, nor amenity society spokesmen, will agree about definitions of 'moor and heath' or about 'open country'; and between 1949 and 1981, of course, we have had a shift of concern within society at large that is away from a pure access pole towards a conservation of natural beauty pole. So that in 1981, the National Park Authority charged with dealing in access in 1949, is further charged to make a map of "moor and heath, the natural beauty of which in the the opinion of the

Authority, it is particularly important to conserve." At its last meeting the Association of National Park Officers had before it a paper whose heading was 'Is 1949 moor and heath the same as 1981 moor and heath?'.

OBJECTIVES

I will try and not get you any more deeply involved in that particular argument, but you can guess that I could not let an opportunity like this pass by without registering the problem. I must try to be objective about what is the management need for amenity and recreation purposes as far as upland vegetation is concerned. It is important first that we recognise that both the beauty and the recreational value of upland vegetation depend upon dimensions. The reason that an urban society rates moorland highly is because it is so different from the environment in which that society has to work and live for most of its year. The attraction for the viewer as well as the walker is the space involved. That which is emphasised by the long low profile, the soft summit and thus from its heart the distant enough skyline for 360° from the observer. That distance which allows the great bowl of the sky to perfect the particular experience of beauty. The satisfying dimension will of course shift as one moves position from summit to valley bottom within the moor, but the potential of total space must always be there. We must not forget that for a large number of people the untamed beauty or the beckoning mystery of moorland are most clear to them when viewed from outside, from just across the edge, from beyond the foreground of green fields and trees. Many of them will be content that that mystery should remain so. All of that dimension is just as important to those who do penetrate it, and wish to walk right across it, or all round it, or up and down it at great speeds. For them of course there is another dimension that is critical and that is the height of the vegetation. Knee high for them might create difficulties, so good descriptive words like dwarf, prostrate, close-cropped are very important from the walkers' point of view.

So we appear as a society to need large chunks of moorland that bear vegetation composed of good looking colours, that vary with the seasons, and remain less than knee high. The moorland situation that we have, was created and has since been maintained by hill farmers. For they, until very recently, in their own interests, grazed and burned to patterns. These two processes effectively maintained the dwarf character of the vegetation, and prevented it reverting to the scrubby woodland that it once was.

MANAGEMENT PRACTICES

As far as grazing is concerned, it needs to be continuous during the growing season for obvious reasons; and stocking rates need to be such as to maintain a pressure which is not maintained by selective grazing. If the sheep or the cow

can pick and choose then eventually the vegetation community will change, and that change will not be for the better as far as the amenity is concerned. Burning was doubtless the instrument of the original clearance and has proved necessary since, because the stocking rate has never been ideal, partly because that must depend upon the relationship of in-by land to moorland grazing either within one holding, or as common right grazing associated with the holding. Burning is now necessary to interrupt the natural life cycle of *Calluna* say, to encourage both new shoots from old stock, and germination in the light, *before* the natural collapse of the original heather plant. After ten years that original plant will be valueless from a grazing point of view, but it will still play an important role in both sheltering and hiding wildlife of various kinds. South of the grouse moors there is no vested interest in elderly heather, but the segment of society interested in the maintenance of habitat and populations of, for our purposes, upland birds, is growing rapidly. The manager of moorland for its natural beauty will ignore the nesting site of the golden plover, the dunlin and the merlin at his peril.

DARTMOOR AS AN EXAMPLE

My experience is limited but if I may tell you briefly of the Dartmoor situation I think it is not without its parallels elsewhere. Burning is now a folk memory on Dartmoor, those who still indulge it burn the same areas regularly, or deliberately set out to burn off that characteristic winter raffia that is *Molinia,* or leggy gorse. Accusations of over-grazing are also regular, but over-grazing evidence is confined to roadsides, that small area of moor just inside each cattle grid and sometimes the site of last year's fire. Within 200 yards of any over-grazed site you can be knee deep in clearly under-grazed vegetation. The cost of labour is clearly at the bottom of both these problems. It is in many ways too easy to collect hill farming subsidies now, without carrying through the practices that go with good stockmanship. We have far too few good shepherds, good herdsmen, moormen, agisters and all those people who between them maintained the moorland, at least in the state which has allowed it to survive to our own time through perhaps 100 years of diminishing attention.

To maintain the upland vegetation in its ideal state from an amenity point of view, only demands the same processes as would maintain it in an ideal state from a hill farming point of view. That hill farmers have not had to indulge in close shepherding and herding and programmed burning is a commentary perhaps on the effect of society's handling of agricultural finances since 1947. I have no doubt that the relevent European Economic Community directive could have been used to invigorate these processes in the hill farming community. Instead, European money has brought about pressures in the hills which appear to be attempting to change the upland vegetation and reduce its available area. The Exmoor situation demonstrated this, and the financial calculations that went with that process have led us further on down a particular

alley that seems to be intent on paying farmers not to do things, the profits from which were artificially created in any case. We are faced on Dartmoor with MAFF support for the conversion of moorland to silage-making ground, to increase the headage carried on particular farms. On a 600 acre farm of which 400 is moorland it is proposed that 160 acres of that moorland should be converted for silage production. At the same time the in-by land should go into an arable rotation of 7 years involving 7 ten-acre-blocks which will produce four years of grass, a year of roots, a year of oats, a year of roots. All this, it is claimed will support a thousand sheep and one hundred cattle with their followers. Will they be grazing much upland vegetation? In fact the lamb crop could be finished on the roots. In my innocence I had thought that the whole of the support system for hill farming was geared to the fact that that part of the industry was not able to finish a product, but had to sell everything as stores for others to profit from the finishing.

You will forgive my cynicism. Do not however misinterpret me. My next brother farms, and my eldest son is at the moment training to. I am full of sympathy for farmers, but the image of the steward which some farming organisations wish to promote is just a little tarnished at its edges. I see that the surplusses we have been producing in Europe are now beginning to be recognised by officials high in MAFF, and papers have been read during this summer about the possible need, in the near future, to reduce the intensification of the farming industry. The relevance of all this story to your conference and the title you asked me to speak to is that I suspect that a reduction in intensification will not be applied equally over the whole industry. There are those, after all, whose whole enterprise is intense and to ask them to reduce it, might be to ask them to go out of business. Even in this recent period of surplus production, wealth has not been easily available to the hill farmer and survival in the face of growing farm debts has been his main concern. Silage production is guaranteed annually, where hay making is a risk, so the shift to silage production is readily understood. That it should be encouraged to develop at the expense of the base of the hill farming industry, which is the moorland, is the worrying thing.

The attempt to deal with over production could see a withdrawal of energy from the hills; while it has been nice to claim that amenity and agricultural needs in the hills converge, that may not be for very long a safe bet. So to achieve the right management of moorland vegetation in the interests of society as a whole and for whatever purpose, the management agreement may well be the answer but not in the sense that it is used in the 1981 Act. In the conservation boom of the early 1970s many farmers said to me that they did not wish to be paid for doing nothing, or more accurately: for not doing something. The 1981 Act gears its management agreement to compensation for non-conversion of moorland. It would have been so much better, and it may now be necessary, to create a legislative management agreement situation to achieve the desirable maintenance system. Society will have to inject money into the hills, not as an acknowledgement of, and redress for, loss of profit; but as a wage, a rate for the job of managing the grazing and burning machine.

RESEARCH

I was asked to touch on research needs under this subject heading. We still need research into optimum stocking, in quantity and quality, on different vegetation associations, just as each of the ten or so associations present on Dartmoor probably demand different burning programmes where they need burning at all. We also need some research into public perceptions of the need for management and public understanding of the management techniques necessary. Perhaps I could pull all this together by reference to bracken.

Everyone appears to agree that bracken is invasive and that that invasion is observable now. I have always argued that bracken is like starlings and sycamore, a very successful species. It is not popular. It supports only 14 invertebrates, all of which land on your sandwiches, it wets you to the armpits in late July, it is a carcinogen and poisonous to mammals. It looks good for about 14 days when it is dying. Briefly in the early 1970s, asulam was within reach of many hill farmers. The helicopter could just be afforded for those with a big enough estate (aerial spraying is the only sensible way to deal with invasive bracken on rough terrain). Since then in the south certainly, little spraying has gone on. Interestingly, at the first proposal to spray bracken there was an amenity outcry geared to chemistry and water supply. In the decade since the first proposal on Dartmoor those who opposed it have changed their view, and now in 1982 are asking for bracken to be controlled.

Research is needed into the economics of the spraying operation now. Are alternatives available and feasible? Does the amenity bracken control lobby understand the processes available? How should the process be funded? Enough bracken for whinchats will be retained on rocky slopes and within 'bracken-and-bushes' enclosures, but a sizeable area of open bracken covered land should be tackled soon and that leads to the final, and general, problem.

Given that the total areal dimension is a critical characteristic in the amenity and recreation quality of upland vegetation, and the need to keep that vegetation below knee height is paramount, and the agricultural need to do the appropriate work is probably diminishing, then how should the optimum be achieved, and maintained?

PROBLEMS

Is there scope for management agreements in which 'amenity authorities' pay for farming endeavour, in a park-keeper sense? – like the MoD paying farmers as range clearers.

Is there scope for voluntary labour deployment in the burning, cutting or trampling operations component of control? If so, how should complementary grazing be managed – or even achieved?

Does the 'amenity authority' in the end have to become the effective owner, and employ statutory shepherds/keepers, and own the flock or the game, with

its public purse bearing the costs/losses involved in the maintenance operation? There might of course be lease-back options with the right conditions attached in better hill farming economic moments.

In all this, beware the special problems of common land management which all parties still do not face fairly. If legislation (private or public) gives a public right of access to common land *without* parallel obligation for management devolved upon some effective agency, then upland commons will follow many lowland commons into the thicket stage.

Given that, despite the claims that peace, quiet, solitude are major desires; moorland users nevertheless appear to want, as to the majority, to move in the mass, is there then scope for sponsored swipes, burns or tramples of vegetation on commons?

DISCUSSION FOR MR MERCER

Mr Eadie I was delighted to hear your references to the importance of man in the ecosystem, and especially in the hills where man may be the most threatened species. His problem is an economic one. Could you deliberate a bit more about the oscillations of activity in the uplands, and comment on the need for wider objectives for management than the agricultural interest. I have some difficulty in seeing that these wider objectives, if they constrain agricultural development too much, will be compatible with the economic well being of the people about whom you are concerned.

Mr Mercer (Speaker) Whilst most of what I said was about the actual physical oscillation of vegetation, it is absolutely right that this reflects oscillations in the human population. With reference to advising on management, we are dependent on the management systems that we know about, and in places we need to try to re-establish methods of management – such as burning, shepherding, and the traditional grazing systems with stock – that are now disappearing. The problem is a human one: many farmers don't wish to be paid to do nothing, or to work inefficiently as they see it, although some of them are prepared to be paid to take on other jobs, such as range wardens on the MoD land on Dartmoor. In this sense the principle of a hill farmer accepting another function besides farming is becoming established. But there has got to be a shift in general agricultural opinion for this to go very far, and more support from society for what it wants out of the hills. We need the agricultural gains in the uplands, but they will always oscillate in their productivity, and in the return to the farmer. Maybe we should try to arrange things so that there is a consistent return for those who live and work in the hills, with a contribution from amenity when agriculture is down, and a reduction in the contribution when hill farming is booming.

Mr Smart Does your experience of the multiple pressures and conflicting needs of land use suggest to you the need for a consensus, or coherent view, such as existed in the 18th century, but which does not exist at present, in order to provide a framework for the uplands? Have we a reference point from which we can evaluate competing interests such as you describe in your paper?

Mr Mercer (Speaker) I am sure that the population of minds from which the consensus was obtained in the 18th century was smaller than the consensus of minds that is now playing on the environment. The 18th century landowner was dominant, and whatever one's attitude to their social position, they made a huge contribution to the environment that we now enjoy. What we need is an unified consensus that is a substitute for that, and I don't know where you get it. Many of the lobbies and organisations that are supposed to support amenity authorities don't support them at all, and in fact treat them as much as a butt for their criticisms as organisations such as the National Farmers' Union, that are supposedly the natural opponents of the authorities. There is a terrible bigotry amongst the people who are the high-minded defenders of things that they don't actually have any responsibility for, that makes the job of those that do have responsibility almost impossible. A lot of the difficulty in getting a consensus is tied up there somewhere.

Dr Holdgate In many upland areas, visitors are now making a substantial financial contribution to rural communities. How far are Dartmoor farmers adapting their management systems to cater for visitors as a sort of subsidiary crop – for example by providing for pony trekking, by making access routes that steer people away from productive farmland, and by making other areas positively attractive to people?

Mr Mercer (Speaker) It certainly is a feature, but its not universal. The Dartmoor Tourist Association, which is representative of perhaps half of the people involved, claim to be turning over £4.5million in a year from tourism within the National Park – so if that's half, then maybe the total is more like £9million. If the stock on the hill is worth £7million then you can start to make comparisons.

As far as other ventures are concerned pony trekking is popular, and the ponies can be stabled in buildings that would otherwise be redundant agriculturally, which is an useful way of keeping another bit of the heritage actually in use.

There is no doubt that in some areas, on the most popular commons for access, sheep are being displaced by people. There is a very big problem with dogs, which are a major problem and there is a need for a consensus on how to deal with them. I accept the principle that if people are mixed with stock, then people must not be able to physically drive the stock out. As a consequence, in areas where people can roam at will (as opposed to being confined to bridleways and footpaths) there must be a stockproof fence, maintainable by the amenity authority. In one area we have a draft agreement that dogs will be kept out to prevent disturbance to stock; this is going to upset local people, who walk their dogs on this land now, more than the ramblers. In another case I know of a farmer who has had to modify the management of his sheep – his ewes and lambs – within the last six years because of the dog problem. He is looking for compensation for having to modify his management, for losing flexibility, which ultimately affects his farming capacity.

Mr. Barber (Chairman) There are very wide differences in the popularity of Bed and Breakfast in different parts of the country. We tend to think of the uplands as being an uniform sort of land, but they are nothing of the sort, with many different kinds of land use and people who inhabit them.

Professor Moore Farmers in the less favoured areas are supported financially for social reasons rather than agricultural ones, yet they get their support through the agricultural departments, and this can have unfortunate environmental consequences. Many of us agree

that it would be better if they were to receive money to look after the landscape and wildlife, as well as farming. There are psychological difficulties about this – would farmers on Dartmoor accept this kind of role?

Mr Mercer (Speaker) I think that it is coming, and that perhaps initiatives like Uplands Management Experiments, will bring about the acceptance amongst hill farming of the idea of money for other purposes than farming. There is great scope for co-operation between farmers and the voluntary organisations, for instance in the building of stone walls, or the control of bracken which is regarded as a nuisance by both farmer and rambler alike. In this way money, and management, can be used for social and economic purposes. If common interests can be fostered between the farming and the amenity sides, that surely is a way to begin to bring out the principles of land use that lie behind their respective interests. I am sure that we should be trying to achieve this, and if we can act as a catalyst in doing so, that will be a good thing.

Mr Barber (Chairman) The Countryside Commission is initiating a series of debates on the uplands, starting in the New Year, with the intention of reporting to Ministers in October 1983 on the results. There will be meetings with farmers, the tourist industry and other interested organisations, in order to try to come to a reasonable view of how their differing interests can be brought together.

More provocatively now, I would like to propose the question of whether or not we are making too much out of the so-called wildness and openness of *some* of the hill country. I accept the argument wholly in *parts*, but I am worried that more and more people are saying that all the uplands should be sacrosanct, with no fencing and no development. I question this very much, and, because there are such wide differences between one area and another of the upland I think that we have got to be much more objective. In some areas agriculture introduces diversity and interest into a scene which might otherwise be uninteresting to a degree, and often degraded. We have to be careful not to let cleverly orchestrated but uninformed public opinion run us along on this bandwagon too fast.

Dr Holdgate Mr Barber's provocative point can be put still more provocatively. Many ecologists have argued that our western uplands are an impoverished semi-desert, created by our neolithic and bronze age ancestors using the same kind of processes of deforestation that we condemn in the developing world today. Is it responsible of us, in a small densely peopled island, to leave so much land below its natural, potential, productivity? Of course some of it is of great scientific interest in its present form, and more of it depends on its open character for its attractiveness, but a lot falls in neither category. Conservatism is a strong force but a misleading one. It would not be difficult to make the German Black Forest look like the Southern Uplands of Scotland, or the reverse, and the interesting thing is that the change in either direction would be likely to create an equal furore. We need to think coolly about how to make the best use of our limited natural resources, and not to shirk challenges.

Integrated Management of Upland Environment

The Rt. Hon. The Earl Peel
Country Landowner's Association

THE ESTATE

The Gunnerside Estate is situated in North Yorkshire, within the confines of the Yorkshire Dales National Park. It represents a typical cross-section of the upland vegetation, ranging from conventional hay meadows to rough grazing and heather moorland. Altitudes extend from 800 ft in the valley bottom to 2000 ft on the top. The base rock on the Estate is millstone grit with limestone outcrops. A rich substrate relative to the Scottish upland estates.

The ownership of the land can be categorised into three types. Owner occupied land, tenanted land and common land. The Estate owns the sporting rights over all three categories. The common land makes up by far the largest area and produces the greatest percentage of Estate income through the letting of the grouse shooting. There are no farms in-hand.

The freehold of the common land is vested in the Lord of the Manor, subject to the grazing rights of the farmers. There is, in addition, a relatively small amount of woodland, some of which is natural and some of which has been planted recently for amenity and sporting purposes.

The object of this paper is to summarise the management objectives of an upland estate and to highlight some of the conflicts that exist. My comments, therefore, refer principally to the common land (or moorland) and not to the enclosed land (or in-bye) although, from a farming point of view, the two are inseparable.

THE RESPONSIBILITY OF MANAGEMENT

The direct responsibility for the management of these different land types revolves principally around the owner but, due to the varying interests that exist, consultation between interested parties does take place. In the case of owner occupied land, the farmer concerned exercises complete control, though where a conflict of interests is likely to occur with regard to the sporting rights,

the two parties may well come together. On the tenanted farms, there is of course, liaison between the Landlord (or his Agents) and the Tenant. Matters for consultation could include agriculture, sporting, planting, public access and conservation.

On the common land, the Lord of the Manor has prime responsibility, although full consultation with the graziers is both necessary and desirable. Matters for discussion could include grazing pressures, maintenance of walls and roads, drainage, heather burning and public access, plus a number of other less important items. Dialogue is usually best achieved through a management committee, with representation from both parties.

It is difficult to divide the responsibilities of management exactly between these two parties, as it can vary. Generally speaking, the graziers would be responsible for the management of their flocks, including the shepherding, and the maintenance of walls or fences that divide the commons. The Estate would take on predator control, heather burning (sometimes with help from the graziers), drainage schemes and road repairs. The cost of the latter two is likely to be paid for jointly and, if the use of machines were unnecessary, a combined labour force would probably take on the repairs and maintenance.

HISTORY OF LAND USE

In this particular part of the Pennines, the major land use principles have not changed since the decline of the lead-mining industry at the turn of the century. In practice, however, changes have occurred. Traditionally the number of farms was much greater than today (the average hill farm has increased in size by 40% between 1954 and 1973), and agriculture is still the major industry with sheep and cattle continuing to represent the mainstay of the farmers' income.

The land in the valley bottoms is still used to produce hay for winter feed, though silage-making is becoming more prevalent. The rough grazing in the allotments, between the bottom land and the common land, is still used for cattle and sheep but nowadays particularly for ewes with crossbred lambs. Many of these allotments contained purely heather, but most of this has now disappeared. The breeding ewes remained, and still do, on the common land, or moor, for most of the year.

In addition to the sheep grazing on the moorland, grouse shooting was also carried out but mainly as a sport and was rarely considered in terms of financial gain. Records do show, however, that in 1870 grouse shooting was being let at up to £1/brace. More recently, circumstances have changed and the letting of the shooting may now represent a very significant part of estate income.

Since the war, there has been an intensification of agricultural activities and a steady amalgamation of farm units, with the subsequent decline of the local population. These changes have been brought about by the active encouragement of Government to increase agricultural output and the basic need of the farmer to maintain a reasonable standard of living.

The introduction of subsidy payments, so vital to the presence of a viable population, has perhaps been the major catalyst of this intensification, and it is now estimated, from a sample of farms taken in 1978/79, that the Hill Livestock Compensatory Allowance alone (i.e. not including Capital Grants or intervention payments) accounted for 28% of net farm incomes in the less-favoured areas. Since that date, headage payments have increased by 74%.

I do not wish to discuss in detail the political arguments that surround these somewhat contentious points, but simply to put them into perspective with regard to their effects on the economic management of an upland estate where grouse shooting plays such a significant role.

CONFLICTS OF LAND USE

It must be accepted that the grazing on the common land is an integral part of the viability of hill farms, given the average size of the units, but with an increase in grazing pressure on the natural vegetation, conflict has developed.

Over the past 20 years or so, there has been an escalation in commercial grouse shooting. Moor owners are now able to let their shooting for considerable sums of money and a new industry and most welcome source of income has emerged for the upland estate owner.

The major reasons for this development are, once again, the economic pressures on the upland estate, plus the decline of shooting in other parts of this country, and indeed throughout the world, due to the drastic reduction in gamebird habitat. With grouse still surviving in relatively high numbers, and with the opportunity of renting moors now available, the demand is high.

Assessing the primary land use in the uplands depends, of course, from which angle it is considered and there is no doubt that farming is and is always likely to be, the major source of employment. The development of alternative industries, other than tourism, is never likely to succeed in the remoter areas. It should be remembered though that in terms of conservation of the natural habitat, there is no conflict between the needs of grouse and other moorland wildlife.

With the changes in grazing pressure, and the subsequent decline in heather, there has been on many estates a substantial reduction in grouse habitat. Referring to the Gunnerside Estate, there has been a reduction in heather ground from approximately 16,000 acres in 1930 to 11,000 acres in 1980. Generally speaking, decline is associated with changes in three farming techniques. First, more livestock, second, a lack of shepherding so the sheep are no longer evenly distributed over the moor, and, third, winter foddering.

This last point has, I believe, had a much greater impact on the loss of habitat than is generally realised. The problem has been exacerbated through the steady increase in the subsidy payment, thus encouraging the farmer to carry more sheep and having to buy additional hay that the in-bye land cannot produce. This system of feeding ewes on the moor has been developing since

the war, and the result has been that the stock come down to the feeding points, concentrating in large numbers, usually at the bottom of the moor, as this is the easiest point from which to feed the hay. As a result of this, the heather has been wiped out around these points and is receding up the hill. The heather is then replaced by *Nardus* and *Molinia.*

It is interesting to note, however, that areas where sheep have been totally reduced in number, grouse have shown signs of decline. An optimum balance is therefore required, adding weight to the saying that a well-managed grouse moor is a good sheep moor.

A clash of interests can, therefore, exist between the two old established land uses in these areas, although I do believe that, with a degree of mutual understanding and co-operation, these difficulties can be overcome to a great extent. In such discussions, it is essential that, where possible, the social fabric of the uplands be maintained and, without an active agricultural industry, this would I believe, be impossible. Indeed this is recognised only too clearly in the European Economic Community Directive 75/268.

It is, therefore, a question of trying to adapt modern farming methods into a system that will not have too adverse an effect on the natural environment.

In some instances, there is also a conflict between forestry and these other land uses. This has not played a significant role in the Pennines to date, although there are signs that it is beginning to make headway. One of the reasons why it has been so slow in coming is, I believe, due to the rather complicated system of the ownership of the common land. A potential forester, who bought the freehold ownership of the common, would still, of course, be subject to the rights of the graziers and the only affective means of getting control would be to acquire all the grazing rights.

There are other parts of the country, however, and particularly Scotland, where the system of acquisition is straightforward, and forestry has been developing at a great pace.

In view of this country's huge import deficit with regard to timber (over 90% is imported), it is difficult to argue against the need to expand the industry considerably. There are areas which lend themselves more readily to this, and I believe it is socially and environmentally disturbing when potentially good livestock and grouse producing areas are engulfed by trees. This results in a further decline in the upland population, and has a severe impact on tourism. The open moorlands of Great Britain are unique, whereas the endless forests can be seen all over Europe.

Well-managed heather moors, producing sheep and grouse, should together help combat the spread of forestry. However, once this symbiotic relationship is destroyed, generally by the decline in grouse, there is less resistance to commercial forestry. The reasons for the decline in grouse are usually caused by either over-grazing by livestock, mis-management of the moor through lack of burning and/or predator control, or, as in parts of Scotland, the devastating effects of tick coupled with louping-ill virus.

Finally, it should be said that it is necessary to reflect on the wider implications of owning an estate within a National Park. Proper regard for public recreation is now necessary, as is the full co-operation between the estate owner and the statutory bodies whose job it is to implement those Acts of Parliament relating to the countryside.

The following examples show the level of gross output that can be expected from a well-managed moor. I have attempted to show the comparison between a combination of sheep and grouse versus forestry. I have taken a 2000 acre moor in the North of England with the rights to graze 900 sheep (and their followers) and a five-year average grouse return of 500 brace/annum. This should be easily attained on well-managed moors. I have assumed a maximum altitude of 1400 ft, thus bringing the land within the accepted forestry band, although this is considered to be at the upper limits for planting, and not all upland areas, even at this altitude and below, would be regarded as suitable planting ground.

With regard to sheep, I have discounted the relationship between in-bye land and the moorland and simply taken the gross output per hill ewe (these figures are taken from the Farm Management Pocket Book by John Nix) and they include the Hill Livestock Compensatory Allowance currently at £6.25/head. I have taken the capital value to represent the value of the right to graze one sheep plus followers on the moor. The grouse returns represent a combination of the letting value per brace plus the carcase value.

Capital values

900 sheep rights (gaits) @ £50	£45,000
500 Brace of grouse (shooting rights only) @ £350	£175,000
	£220,000
Forestry 2000 acres @ £120/acre	£240,000

It should be noted that if the full rights i.e. grazing and shooting, were combined freehold, as opposed to common land, the value could be increased by 50%.

Gross output

900 Ewes @ £32.60/ewe	£29,340
500 Brace of grouse @ £30/brace + £3 carcase	£16,500
Gross output/p.a.	£45,840

Forestry

2000 acres x single fell final crop of £2000 p.a. at year 50	£4,000,000
Discounted value p.a. over 50 years	£8,750

This does not take into account the substantial tax advantages now available in forestry.

The expected net annual returns, before tax, on the above figures should be in the region of, Grouse 3%, Grazing 5%, and Forestry 3%.

It is perhaps worth noting that since 1954, the capital values of hill farmland have risen 6.8% p.a., whereas planting land has only risen 2.8% p.a.

MANAGEMENT

As this paper relates to the management of the natural vegetation i.e. predominantly heather and blaeberry with outcrops of grass, I have assumed that the purpose is to achieve the maximum output from the moor while, at the same time, ensuring the minimum reduction in this natural vegetation.

In order to maximise the farming and shooting returns, it is necessary to produce good quality heather, high in nutritional value, although this will be restricted to a greater or lesser extent by the fertility of the underlying rocks within regions.

Stock control

As stated earlier, new methods of farming have tended towards high concentrations of sheep in restricted areas, resulting in a loss of the heather. Contrary to this, an understocking of sheep can result in rank heather of poorer quality and a need to burn more regularly. In order to achieve the optimal grazing pressure, it is therefore necessary to encourage the even distribution of the sheep across the moor by producing good quality food throughout, and, in winter time, when the heather is most vulnerable to the effects of sheep, ensuring an active shepherding policy.

It is generally agreed, in the North Pennines, that the optimal stocking rate (when evenly distributed) should be in the region of one sheep plus followers to 2.5 acres, although, ideally, this should vary according to heather quality, the regeneration time, and the amount of grassy, limestone areas.

Burning

The technique of burning is regarded as the most acceptable means of providing high quality heather. The purpose is to remove the old and degenerate plant thus allowing it to be replaced by young and nutritional shoots.

Burning is done at regular intervals on a rotation of approximately once every twelve years, though this will depend on the growth rate which can vary considerably from area to area. If the grazing pressure is particularly great, a burnt area can take many years to recover and it is often advisable not to burn under those circumstances. Fire sizes should be as small as possible, as this further encourages the spread of the sheep and provides a mosaic of

different aged plants so important to grouse. The older heather is used for nesting, protection against predators, and the tips that protrude above the snow line in winter provide a vital source of food. The young heather produces a food supply rich in value, and I believe that the edges created by burning may provide preferred nesting habitat as grouse tend to nest, where possible, within a few meters of these edges.

Nowadays, with the reduction in the labour force on most estates, and the lack of available assistance, it is often difficult to achieve the ideal burning rotations and fire sizes. The number of days burning possible in any given season can be extremely few and many people believe that this would be helped by an extension of the burning season. Research in Scotland has shown that grouse broods seldom move more than 15 meters from the burnt edge, suggesting that the optimal width for a fire is around 30 meters, but this is often impractical if, for the reasons explained, the burning pattern has fallen behind, and thus larger fires may be necessary.

I have explained briefly the significance of burning heather, which, in conjunction with predator control, is generally regarded as the most important management task undertaken by the estate.

An alternative system to burning is the cutting of heather by the use of a tractor driven machine. This method, commonly known as swiping, has a limited use, particularly on the higher and wetter moors, where the high rainfall and difficult terrain make access virtually impossible. Another major drawback of swiping appears to be that the debris left in the wake of the machine prevents fast regeneration of heather and it is regarded as a very expensive alternative to the more conventional 'box of matches'. The major advantages in this method are that there is no restriction as to the timing, other than extreme weather conditions, and as a means of creating firebreaks on moors with a high 'accidental' fire risk due to visitor pressure, or on moors close to forestry plantations where further damage could be caused.

Drainage

Hill drainage has become very fashionable recently mainly because of the highly effective machines that are now in use and, with the generous grants available, make it a comparatively cheap operation. With a density of 8–12 chains/acre, there is a gross cost of 85p/chain, or £10/acre. In less-favoured areas, there is a grant available of 70% reducing the cost to a net figure of £3/acre.

Drainage, or gripping, has always been a recognised part of moor management, although when the work was undertaken by hand, it tended to be more selective than it is today. It is important that the grips are sited correctly, as this will make all the difference as to their effectiveness.

Heather grows better in dry conditions, and undoubtedly gripping can have a direct effect on heather growth. However, from my own personal observations,

I would say that much of the gripping I have seen has had relatively little effect on heather growth and a lot of the increase in heather that has been attributed to gripping has been due to heavy reductions in sheep numbers. Conversely, I do know examples where drainage has been carried out and the heather has improved over a five or six year period without any reduction in sheep numbers.

It is interesting to note that observations by Dr Hudson of the North of England Grouse Research Project have shown that grouse broods frequent boggy patches where the chicks obtain insects (which may be important to their survival) so when considering the needs of grouse, this should perhaps be taken into account. In some areas, a hard impervious pan exists under the peat, which may cause water-logging. In these circumstances, mole drainage can greatly improve both heather growth and quality.

Bracken

It has been said that bracken is spreading at a similar rate to urbanisation, and now that it is no longer cut as bedding for stock, it has ceased to have any practical value.

Aesthetically and as a means of habitat for certain species of wildlife, it has its purpose, but it also provides, through the litter layer beneath the bracken, an ideal habitat for sheep tick, which (particularly in conjunction with the louping-ill virus) has had a devastating effect on grouse and a marked effect on lamb production. Experiments with louping-ill in Scotland have shown that the likely reduction in lamb survival rate between three weeks old and weaning can be as high as 22%. On the same area, grouse breeding density and chick survival rate have both been reduced by 75%. Bracken should, I believe, be prevented from spreading and in certain areas considerably reduced. The spraying of asulam either by air or by hand is an effective means of bracken control, although a second treatment is sometimes advisable and further spot spraying may be necessary in future years to contain any outbreaks that may occur. The cost per acre to aerial spray is £35 (£23 for treatment and £12 for aerial application) and £23/acre plus the cost of labour for manual application. On larger areas it is undoubtedly more efficient and more economical to aerial spray. A grant of 50% is available in less-favoured areas although the Ministry of Agriculture recommend a sensible follow-up treatment to encourage the replacement of the bracken by either heather or grasses. Failure to comply with this would not, however, jeopardise the payment of grant.

Fertilising

Another way of improving heather quality is through the application of nitrogenous fertiliser in the spring. The cost is high and the trials undertaken to date have proved that the beneficial effects last only two or three years.

Furthermore, stock tend to concentrate on the applied areas and severe overgrazing results in a rapid deterioration of the natural vegetation. Consequently, fertilising is not considered as part of routine moor management.

Experiments are being carried out in some areas of Scotland where the quality of the ground is so poor that the sheep are reluctant to graze on the hill and the grouse stocks are minimum. In order to increase the nutrient cycle on these moors, small crofting fields are being re-sown and fertilised to act as core areas from which the sheep disperse onto the heather, and dung. It is hoped that the heather will improve by the distribution of nutrients to the benefit of both sheep and grouse.

Conclusion

I have summarised briefly all the major moor management aspects involving those with an interest on the moor and I have explained earlier in this paper how the responsibilities for management are divided. It is perhaps worth noting that it is generally accepted that one gamekeeper is capable of managing approximately 3,500 acres.

I have not discussed the maintenance of walls and roads for it is usually accepted that these activities, as with heather burning and stock control, would be undertaken by those with direct responsibility for management on the moor. Building of new roads can be extremely expensive though grants are available, and good access is important to successful moor management.

However, without the mutual co-operation of the parties concerned, and an understanding for each other's needs, the success of any scheme is likely to be jeopardised.

FINAL COMMENTS

When considering the future use of the less-favoured areas of Britain, the principal aim must be to attempt to reconcile the major interests. There is a need to maintain a healthy agricultural industry, thus sustaining a local population, though the level of output which can be justified in terms of agricultural need and its effect on the environment is perhaps the major issue.

It is generally considered that there is a requirement to re-examine the structure of the subsidy system and it has always seemed to me a waste of resources to find potentially productive lowground enclosures thick with bracken or knee-high in rushes when the moorland areas are often suffering from over-stocking.

The present headage subsidy payments do not necessarily encourage the improvement of such land and one possible alternative would be a switch away from subsidy on the number of ewes in favour of lamb production, although this could be difficult to implement as the rate of payment would have to vary

from area to area. One extreme suggestion is that there should be considerable reductions in the number of sheep in the less-favoured areas and that the farmers be paid a compensatory rate for loss of revenue. In other words, paid not to farm. However, it should not be forgotten that the sheep produced on the hills go to make up a large proportion of the lowland flocks and this cycle is of major importance to sheep farming in general.

There are difficulties in implementing any subsidy system and, in my opinion, the present headage payment could be perfectly acceptable to all concerned, provided certain principles were adhered to. Despite the Commons Registration Act, over-stocking is one of the difficulties. There should be a compulsory period on all commons when they are completely free of stock to allow proper regrowth to take place, and more control is required on winter foddering for the reasons I have given earlier. I share the views of many people that the subsidy system needs tightening up in order to reflect more accurately the number of stock that any one farm is capable of maintaining without a resultant decrease in the natural vegetation.

This subject can produce endless debate but, in my management capacity, I have to work within the system which is prevalent and, therefore, my aim is to try and compromise the changes in modern farming practices with the need to conserve heather for grouse production. As I have already mentioned, shooting and conservation are compatible and it is fair to say that shooting as the protector of the natural environment is such that, without the sport, large tracts of heather ground would have long since disappeared.

Although I believe there is room for improvement in some of the enclosed land, any question of increased production on the moorland could only lead to a further reduction in the natural vegetation, the likelihood of erosion and the degrading of the aesthetic value. There is also evidence that there are areas of in-bye land which are suffering from an increase in stocking pressure, so it is difficult to make fixed rules for one area against another.

With regard to the potential for increased grouse production, this would largely depend on the maintenance of heather and the number and quality of keepers employed. However, there is still a great deal which is not fully understood about grouse and, consequently, through The Game Conservancy and under the surveillance of a Steering Committee, the North of England Grouse Research Project has been established to conduct a seven-year investigation into all aspects of grouse moor management. The ultimate aim of the Project is to eliminate the crashes in grouse numbers that exist on most moors and thus improve the 'cash flow' position. Particular points that are being examined are the effects of the disease, strongylosis, on the population dynamics of grouse, the importance of insects as a food supply and what sort of shooting pressure a moor can affectively sustain.

Much work on grouse has been undertaken by the Institute of Terrestrial Ecology in Scotland and, although conditions are very different, it is hoped the combined efforts of both inquiries will help to improve the management techniques on grouse.

There is also an urgent need for research to help counteract the devastating effects of sheep tick and louping-ill virus in connection with both grouse and lamb production.

I have mentioned tourism briefly and it is an accepted fact that the pressure on the countryside will increase and the actions of those owning and managing land will become more accountable to the general public. In some ways, I believe this could be beneficial. However, mutual respect is the key to a successful relationship and I feel that the automatic right of public access to the uplands could seriously impair this respect. In addition, I feel it could undermine much of the intentions of the Wildlife & Countryside Act, 1981.

The difficulties in exercising sensible control and maintaining a balance between tourism and local needs already prove a difficult task which the National Park Authorities carry out to the best of their ability. Automatic public access would make this task even more difficult, and the general disturbance, potential damage by dogs at certain times of the year, and increased fire risk would add to the existing conflicts.

In any community, there is generally some degree of internal, and external, conflict and I see one of the major objectives of management as trying to reconcile these various interests.

DISCUSSION FOR THE EARL PEEL

Dr Holdgate (Chairman) At the beginning of the meeting I was worried that we would spend about two-thirds of our time discussing the less than one-third of British semi-natural vegetation that occurs in the lowlands. I was also worried that we would focus too exclusively on wildlife conservation, and forget that much semi-natural vegetation is managed to yield a crop – usually an animal crop – and hopefully in a fashion that is compatible with other interests in the environment. Lord Peel's paper does deal with these kinds of wider issue which arise in the management of the broad tracts of semi-natural habitats in the uplands. Mr Christensen's paper beautifully complements Lord Peel's, because it brings us down into the farm lands, and confronts us with the sorts of problems with which Mr Clegg was dealing. These two papers have therefore given an opportunity to pick up and draw together themes that have been running through the whole meeting.

Mr Small Is Lord Peel anti-tree, or more specifically anti-conifer? Would he accept that if the system of management of his kind of land fails in some way, some other system, such as forestry, should be introduced for the benefit of the country.

Lord Peel (Speaker) No, I am not anti-tree. The point is that there are plenty of areas in the uplands that are not suitable for productive farming, or for grouse. Let those be the areas where trees are established. Otherwise the whole of the uplands will be covered in trees, and this would have a serious effect on tourism, the whole population of the uplands would suffer, and we should lose a vital part of our heritage.

Mr Eadie The central problem you describe is a social problem and not a technical one. It arises from the use of the moor for grouse on the one hand, and of the same moor for hill sheep farming on the other where the two activities are in the hands of different people with different objectives.

Three problems have been raised in regard to the management of heather. In the first place you suggested that the heather was being affected by increases in the number of sheep. Now at the current stocking rates of 2½ sheep to the acre, I don't think that an increase can be a cause. One sheep will process about 700 kg of dry matter in the course of a year, whilst an acre of heather will certainly produce 2,500 kg and may be up to 4,500 kg/acre. So that 2½ sheep cannot possible provide the grazing pressure that will put the heather in any danger. Heather moor is not really so fragile as many people think, and if one does get to a point when it is being affected, heather will quickly come back following relaxation of grazing pressure.

Secondly, you commented on the lack of shepherds. The lack of control of grazing could be a factor, but on a badly burnt moor the sheep will selectively graze a very small proportion of the area, to a point at which the optimal utilisation rate will be exceeded and damage will be done. As a consequence much depends on burning management. At some stage a proper burning cycle must be implemented.

The third and most critical factor is the winter feeding practices you describe, in which stock are concentrated for longish periods on quite small areas of land. This problem can be solved by block feeding, but the difficulty is to persuade farmers to do this. It may mean a change in farm practice, but it has been accepted in other parts of the country and the problem is not a technical one, but social.

Lord Peel (Speaker) I agree that the problem is a social one, but this does not alter the fact that thousands of acres of heather are being lost each year. This does not mean that there is an objection to subsidy payments, which are vital to the viability of the whole upland environment. One sheep per 2.5 acres is optimal, but where this rate has been increased to a sheep on 0.8 acre there is a problem, even on the best moors. If there is overstocking of sheep, heather is lost. Foddering of sheep in a fixed place results in heavy concentrations of numbers and the worst combination possible – that is too many sheep on the lower slope and too few on the top.

On the point about block feeds, if they are distributed evenly across the moor, they can act as a means of dispersing the sheep. Persuading the farmer to do this is the problem. So often block feeds are put down with the hay, which exacerbates the problem, because as soon as the sheep go for the block feed they want roughage, and turn to the heather.

Mr Eadie The whole question of appropriate stocking rates on the heather moors is critical and complex, because usually we are not dealing with a heather monoculture, but with a mixture of vegetation types. But it should be possible to make a sensible analysis of your problem.

Lord Peel (Speaker) Yes, the mixture of vegetation is the best you can possibly get for grouse and for sheep. But, if one is going to talk about research, the problem of stocking rates is something that really ought to be looked at.

Mr Eadie What is needed very much more is the application of existing knowledge. There is plenty of information, what is needed is more effective ways of communicating it.

Dr Holdgate (Chairman) How effectively are the results of all the research that has been going on for years, being applied in practice? There are presumably ways in which this information can be put to hill farmers through The Agricultural Development & Advisory Service (ADAS), but how much of it gets through to your tenants?

Lord Peel (Speaker) I don't think that ADAS has really been involved in the particular problem of management of heather moor, for grouse and sheep, in our part of the country.

Dr Holdgate (Chairman) Advice on one component of a complex system should take account of other components, especially when these have also major economic importance.

Mr Wyatt With respect to Lord Peel's reference to the Derby Moors in his paper, we (ADAS) are setting up some work now with the Peak Park Planning Authority to look at their problems of erosion. I don't accept the report that has been produced, saying that sheep farmers are to blame. Whilst the statistics do show that there are more sheep, it is not possible to say from the data where on the moor the sheep are located, as the figures relate to the home farm. Whilst sheep may be responsible for some of the damage, most of the erosion is much more likely to have come from the impact of man. Accidental summer fires and 70 years of air pollution will also have had a significant effect. So it is too easy, and probably not true, to say that the sheep farmers, and too many sheep, are to blame.

Certainly the management practices have changed. Traditionally, sheep were moved around much more to give the heather a periodic rest. Also they came down off the moor earlier in the winter than they do now.

On the problem of transferring information, and giving advice; ADAS does put out a lot of information, but at the end of the day this can only be as practical as the use that farmers make of it. And this is true not only of farmers, but of other non-farming organisations, such as planners, with whom ADAS has to deal.

Thus, whilst I accept that sheep have something to do with the changes in the Derbyshire Moors, I don't accept that they are the prime cause of the changes, and I think we need to look much harder at what is going on up there on the open ground.

Lord Peel (Speaker) I don't blame the sheep farmers, for the system under which they have to operate is so open to abuse. Headage payments encourage the maximizing of the numbers of sheep beyond the limits of good husbandry, and this has been evident over the past 12–13 years.

You mentioned the question of rest periods. Very few moors now get the necessary six or seven weeks in the spring, which is so vital to the regeneration process. If this alone could be re-introduced, it would go some way to solving the problems.

Mr de Salis Lord Peel has made a powerful case for grouse moor management that involves both grouse and sheep. What are the implications of this for employment and the local economy?

Lord Peel (Speaker) The effect on the local economy from grouse shooting is very significant. Not only is one employing gamekeepers, but when one is involved in what might loosely be called commercial shooting, then there are all the visitors, many from abroad, to the house and often to the village shop, providing extra opportunities for employment and bringing in additional trade.

SCRUB and FARMLAND HABITATS

Management of Natural Vegetation on Farms

P. A. Christensen
Kingston Hill Farm

"Natural" vegetation on farms can be divided into three categories:–

(A) Vegetation that has a direct benefit to the farming operation.
(B) Vegetation that has a direct adverse affect on the farming operation.
(C) Vegetation that is passive in its effect on the farming operation.

The situation is further complicated by the fact that A can become B under a different farming system, the classic example being the hedge; highly valued and nurtured on the livestock farm and grubbed out on the arable farm. C can be passive under certain situations, for example, the rickyard on a livestock farm, but is definitely B on the arable farm where it is a reservoir of problems from thistles to sterile brome! From these observations it is obvious that to draw general conclusions for all farming systems is fraught with difficulty. It is however important to recognise the categories shown above, as they will greatly influence a farmer's attitude to his management of natural vegetation on his farm. He will probably use time honoured and traditional methods of management for all areas in category A, and be ruthless and cavalier in his approach to B and probably C.

This question of the farmer's attitude is very important if we are to ask him to manage natural vegetation on his farm in any other way and for any other purpose than a strictly agricultural one. His management objectives with regard to natural vegetation have historically been to maintain hedges to turn stock, to maintain ditches to run water, to maintain woodland edges so as not to encroach on his cropped area of field, to maintain verges for tidiness and so on. The methods of managing these areas have evolved as mechanisation and spraying techniques have developed. As more and more farms move over to cereal farming, and the cereal 'belt' moves ever westward, then the management of natural vegetation on farms becomes easier, because of the technological developments and because there is less of it to manage! So what is the problem?

The problem is clearly one of a shift in management objectives with regard to natural vegetation, and the major shift is towards conservation and amenity objectives. Whether we like it or not public opinion will more and more affect

our decisions on what we do on our farms with regard to the landscape and wildlife. It is also true that the vast bulk of the wildlife lives within our farm boundaries. There are those who say that because farming requires to raise to, and maintain fertility levels on, a high plane, then the cause of wildlife in our lowlands is a lost one, as the requirements of wildlife are a low plane of fertility. This point of view I cannot agree with. It is quite possible to maintain natural vegetation on farms run intensively and profitably, at a very low level of fertility. It simply means ensuring that the farming operation does not encroach into the areas of natural vegetation. Public statements of pessimism on the chances of maintaining a rich wildlife in lowland Britain fosters the attitude among the only people who can do anything about it – the British Farmer – that the cause is already lost. This is not so, and is amply demonstrated by many examples of the successful integration of wildlife considerations on commercial farms.

The fact of the matter is that on our own farm more and more of the vegetation management falls into the 'conservation' category, and we are woefully short of expertise on how best to carry out this management to optimise its contribution to wildlife. We, as an industry, are continually being beaten over the head by sections of the community who demand that we have more regard for wildlife in our farming operations. But, it seems, no one has yet come up with a set of clearly defined management rules to ensure that natural vegetation on our farms fulfils any conservation objectives. We must be able to turn to the Agricultural Development and Advisory Service (ADAS) and ask for their conservation adviser, who will be fully conversant with the practical aspects of natural vegetation management. He in turn must be able to have access to research work carried out to find maximum effect/minimum cost methods of vegetation management.

It is time that Government set up a project at one of their research stations specifically to look at the management of natural vegetation, with a wildlife objective clearly defined. The Weed Research Organisation at Yarnton in Oxfordshire would seem to be a sensible place to carry out such an investigation, as they already have great expertise in the control and manipulation of vegetation within field boundaries. An extension of this work to the whole farmed area would seem logical and necessary. One area that needs urgent and active action by such an organisation, is the current practice of spraying-off an area around the perimeter of a cereal field to prevent the encroachment of sterile brome and other weeds into the growing crop from the hedge bottom. This practice, which is very effective in its objective, is also devastating to the flora in the hedge bottom if the operation is not carefully carried out. Not only are the weeds prevented from invading the crop, but all the other non-injurious plants are also killed right up to the rootstocks of the woody hedge species themselves. This is a classic case of an excellent technique destroying valuable wildlife because of poor application methods. In so many cases this sort of destruction could be avoided by communicating to the operator exactly

what his objective was, and the effect any inaccuracy on his part would have on the wildlife of the farm.

The setting up of this project is a matter of some urgency. There is growing evidence that farmers are becoming increasingly aware of their responsibilities in wildlife conservation, and are leaving areas of natural vegetation specifically for their wildlife contribution, and in many cases are actually planting up areas of their farms. When they turn round and ask in a year or two how to best manage these areas, someone needs to be able to give them the answers!

Because of the difficulties of generalisations I will now restrict my comments to the management of vegetation on our own farming operation, which carries both livestock and an arable enterprise, and has a wide range of natural vegetation including river banks (River Thames), ditches, hedges, ponds, tracks, scrub, woodlands, the farm yard, rough grass and road verges. The farm is approx. 700 acres (284 ha), is owned by St Johns College, Oxford, and we have been tenants for 14 years. It carries a herd of 350 dairy cows, 450 beef and dairy replacements, and 100 acres (40 ha) of cereals. It is situated 8 miles west of Oxford, and has the River Thames as its northern boundary.

Our farming objectives are to be adequately profitable at the same time as increasing our net worth. We have thought about a wildlife objective and have set ourselves the target of leaving the same number of species of wildlife at the end of our tenure as were present when we started. Clearly any management methods applying to natural vegetation will be tempered by both these objectives, and it would be fair to say that our attempts are probably very clumsy and in some cases may be failing as regards the wildlife objective. This is where we need the specific advice!

How do we manage these non-crop areas on our farm? The first general principle is to try to ensure that our farming operations do not affect the areas of natural vegetation except where they are part of it. The obvious examples are spray chemicals and fertilisers. Spray drift, and its dangers, are well enough documented, and the current research into more accurate and drift free methods of applying chemicals must race ahead. It is surely not beyond the wit of man to be able to apply a chemical where and when he wants to, given the will to succeed. At the moment it is just the application machinery which is lagging behind the need to be more accurate. I do not consider it to be a responsible action to release a chemical into the air in such a form that we rely on natural agencies to distribute it for us. That chemical, drifting free across the countryside, could have long term effects we never dreamt of. In our own case, we try to ensure that our spraying operations reduce drift to the minimum, keeping well away from sensitive areas. But our efforts are very crude.

Less obvious perhaps is the effect of fertiliser on the non-cropped areas. We, in common with large numbers of farmers up and down the country, have for years used a spinning disc type of fertiliser applicator. This has resulted in luxuriant growth of rank grasses in our hedge bottoms, I am sure at the expense

of many wild flowers. I did some sums and came up with the figure that we were throwing 2½% of the fertiliser applied to a 25-acre field into the hedge! Last year we spent £45,000 on fertiliser, and the thought of throwing 2½% of that away prompted us to buy a full width, pneumatic, spreader which hopefully will put our fertiliser where we want it. We have persuaded ADAS to carry out a trial in conjunction with the Countryside Commission to look into the effect of stopping this free *gratis* application of fertiliser to hedges and ditches, and the change in flora which may result.

Other examples where the farming operation may damage natural vegetation unnecessarily are the browsing effects of grazing animals, which must be controlled by adequate fencing, and the application of slurry which should be as carefully controlled as the application of inorganic fertilisers. We believe it *is* possible to raise the level of fertility on the cropped areas and not the uncropped ones!

With the decline in the number of people able to carry out skilled hedge laying operations, and the escalating cost of hand work for any farm operation, the flail cutter is becoming universally accepted as the machine for control of natural vegetation on farms, and is certainly the case at Kingston Hill Farm. Here again the detail of how the operation of the machine is carried out, and the timing of the operation, has a major influence on its effectiveness. We try to cut hedges to an A shape as we are told this has the best wildlife effect, and can create and maintain a stock turning hedge. We try always to cut the hedges in late winter after the birds have stripped the berries and fruits. Cutting the hedges after harvest is in some cases essential from a farming point of view, but destroys a very valuable source of winter food for wildlife. The flail cutter can also be used for the control of verges and rough grass around the farm, and we try to cut once during the growing season. When this should be from a wildlife point of view we are not clear.

As far as ditches are concerned, we have to keep these clear to maintain a good drainage system on the farm. When we clean out a ditch, we do it from one side only, leaving the vegetation on one bank untouched. We also do the ditching on a rotational basis, rather than the whole farm in the same year, to allow re-colonisation to follow the ditcher around. Existing ponds are not filled in, and where a drainage scheme is put in we incorporate the ponds into the drainage system quite successfully. The ponds are kept with an open area of water by deepening them whenever the ditcher is in the vicinity, carrying out routine ditch cleaning. This way the cost of maintaining ponds is very minimal.

Areas of hawthorn scrub on the farm are left to provide shade and shelter for the livestock. These areas require minimal management apart from controlling their spread around their edges, carried out with the flail cutter or a chain saw.

The farm yard is one area where we admit to spraying indiscriminately against all weeds, in an attempt to keep the place looking tidy. Tidiness is our objective, and I must say that we generally fail to achieve this objective!

The river banks in our case need no management as the fields adjoining the river are permanent pasture and grazed to the edge by cattle. Similarly the farm tracks are not maintained in any way as far as natural vegetation is concerned, as the passage of vehicles and livestock is sufficient to keep them open.

What does it cost us to manage the natural vegetation on the farm? We use a contractor for both the flail cutting and ditching operations on the farm and last year the cost of flail cutting amounted to £436, and the ditching to £350. These can be regarded as annual charges and work out at a little over £1 per acre. We estimate that of this total, £165 can be attributed to alterations in our methods to specifically cater for some wildlife considerations, hardly a sum to break the bank!

To summarise then, the objectives of natural vegetation management are moving away from direct farming requirements and towards conservation objectives. This must be recognised by Government, who should urgently look at methods and techniques of management to fulfil these objectives. The Ministry of Agriculture, Fisheries and Food (MAFF) should continue the momentum of fully briefing field staff to convey the information to the farmer, and just as important, to the farmer's staff. The farmer must recognise his responsibilities, and respond to them positively, seeking advice from his ADAS man whenever he needs help.

Given this movement, natural vegetation on farms will continue to serve its farming functions, at the same time as providing an essential reservoir for wildlife. We must farm the fields for food and the natural vegetation for posterity!

DISCUSSION FOR MR CHRISTENSEN

Professor Moore Mr Christensen drew our attention to two major problems concerning pesticides and fertilisers. We are not able to apply pesticides accurately, and we do not know what are the effects of drift and overspraying. I believe that the reasons why we are not getting the research done is because the problems overlap the remits of several funding organisations – that is the Agriculture departments, the Department of the Environment (DOE), the Nature Conservancy Council (NCC) and the research councils. Is there any hope of these organisations getting to grips with these problems together? I should like to address the question to the Chairman.

Dr Holdgate (Chairman) It was partly with the need in mind to make certain that important matters bearing on the countryside did not fall down the cracks between the main agencies, that we had a meeting earlier in the year with the Country Landowner's Association, National Farmers' Union, Countryside Commission for England and Wales, and the Countryside Commission for Scotland, NCC, the Forestry Commission and our own people from the DOE.

So far as research is concerned, it is my personal view that the job of DOE is particularly to see that important work that cuts across the interests of several agencies does not get missed out. If anyone here has a particular proposition for us to consider I will be very glad to hear it.

Mr Fryer I should like to endorse Professor Moore's remarks about the need for positive planning and co-ordination of research at national level, together with appropriate funding, to ensure that new techniques of management are made available. For the past three years the Countryside Commission has generously funded our work at the Weed Research Organisation to explore the potential value of herbicides and growth retardants for the management of semi-natural vegetation, but this funding is coming to an end. For six months we have been exploring with the Commission, with the Agricultural Development Advisory Service, with the Agricultural Research Council, and with MAFF Chief Scientist's Group, ways in which a research programme could now be funded to investigate management practices for use by farmers like Mr Christensen, who are interested in combining crop production with wildlife conservation. But there are many difficulties. It really is most important for the Heads of all the relevant agencies to get together to determine what research needs to be done, and to find mechanisms, and money, to allow positive progress to be made.

Mr Beckett The British Agrochemical Association (BAA) and the Agricultural Engineering Association (AEA) are working positively together to improve the ability of the spray operator to place agro-chemicals precisely upon the selected target. Accent is being firmly placed on solving the problem of practical application techniques, and this places great emphasis upon the operator. It is our firm belief that the training of spray operators is of paramount importance, whatever type of application equipment is being used.

Mr Haythornthwaite Could I first thank Mr Christensen for his co-operation in the Demonstration Farms Project; it is much appreciated by ADAS. I would like to assure him that the conservation work of ADAS will be carried out by all the Services, and not just by the Land and Water Service. The involvement of ADAS has been increasing since the 1968 Countryside Act but, although conservation training continues, ADAS will still look to the conservation bodies to give specialist advice to farmers when the need arises. I would expect the ADAS officer to introduce the specialist to the farmer rather than just hand the farmer a list of names and addresses of appropriate people.

Both Mr Christensen and Mr Carter have referred to the importance of the attitudes of farmers towards conservation. Mr Carter referred to research that I did in 1975, and I am planning a follow-up exercise in 1985 to see if, and how attitudes have changed. One of the things that the 1975 survey showed was (contrary to popular belief) that farmers were as likely to conserve wildlife for its own sake, as they were as an incidental spin-off from their interests in sport. I should be very interested to hear from Mr Christensen why he has decided to incorporate conservation strategies in his farm management plan.

Mr Christensen (Speaker) I don't know – and thats an honest answer. We all react when we hear that some animal or plant somewhere is on the point of extinction, and throw up our arms in horror, and think that somebody should do something about it. I suppose we should look at our farms, or our gardens, or whatever it is, as if it was the whole world. Thats the best answer I can give.

Dr Holdgate (Chairman) Yes. I think that even in a scientific meeting we should not expect formal scientific reasons for everything. I think that a lot of people who protect nature and who try to keep the place beautiful, do it because they like it – and that's as good a reason as any other in my view.

Mr Small It seems to me that conservation in this country will survive because of the practical conscience of the managers.

In the last paragraph of your paper you say that natural vegetation on the farm will continue to serve farming functions. Is conservation to you a luxury, or are there aspects of it that really help your farming management?

Mr Christensen (Speaker) There are many areas on the farm when natural vegetation is a direct benefit to us. In our particular case we are a stock farm, and hedges are of vital importance to us to provide shelter and shade. We also winter cattle on a belt of light sand through the middle of the farm, and winter shelter is particularly important to them. We are re-establishing a diversity of trees to replace the uniform stands of elm that we had before Dutch Elm disease struck us, again to provide shelter, but we have now taken the opportunity to introduce diversity which will be more valuable for wildlife.

Mr Gilmour Do you stand back and consider your farm as a part of the landscape, and do you intentionally carry out alterations with landscape effects in mind?

Mr Christensen (Speaker) It is a part of the landscape, but I do not stand back and look at it as such. Landscape is so subjective a thing that to be dogmatic about it is fraught with danger. If you gave 700 acres to the 70 people here and asked them to design a landscape for it, you would get 70 different landscapes. Our objective for the farm, which I gave at the beginning, to leave as many species at the end of our tenancy as when we started, is very carefully thought out. That is an objective which I think is much more important than a visual landscape, because the landscape, if you fulfil that objective, will look after itself.

Mr Carter As a further comment, may I observe that the present landscape has been shaped by the individual decisions, over many many years of landowners and land managers. This is likely to continue to be the case. Consequently, it is essential that individual landowners and occupiers are informed of, and aware of, the need for management of the total environment, and that everything possible is done to secure their goodwill and co-operation.

Management of Hedgerows and Scrub

E. S. Carter
Farming and Wildlife
Advisory Group

HEDGEROWS

The English countryside, with fields divided by hedgerows, provides a pleasant landscape much admired by visitors from other countries, particularly America and Australia, and has been described as like continuous parkland rather than a framework for commercial farming. The hedged countryside is a fairly recent creation, and in the 17th century the landscape was probably much more like that of Normandy and Picardy today.

The English landscape is obviously man-made, shaped by the requirements of farming and the interests of landowners particularly in field sports.

The Anglo-Saxons developed the manorial system with two or three large arable fields having a rotation of one or two cereal crops, followed by one-year fallow. Such fields were often large, perhaps 160–200 ha. Each peasant had rights to strips in the fields and grazing rights on the common pasture.

As the population increased, so more land was reclaimed from the forests, heaths and swamps and enclosed in small fields bounded by hedges or stone dykes.

As opposition to enclosure declined, so more land was enclosed assisted by a series of Enclosure Acts. By 1730, half the arable land in the country was enclosed, especially in Kent, Surrey, East Anglia, Cornwall and Devon and the north-east of England. Open fields still persisted through the Midlands from Yorkshire to Wiltshire and on to the south coast. The landscape here must have been open and bare.

The traditional hedged landscape was not entirely formed through legal Acts of Enclosure. In Buckworth (Cambridgeshire), fields of 30–40 ha in 1680 were, by 1839, down to 6 ha and remained so for 100 years.

During the Industrial Revolution, as more arable crops were required for the towns, fields of 24–40 ha were divided to produce 8-ha-fields and new hedges planted. It was impossible to practice new agricultural methods in the open fields system and the scattered strips were consolidated to provide individual farms.

The Enclosure Acts from 1750 to 1844 with the General Enclosure Act of 1845, resulted in the enclosure of 3 million ha. In a short time the countryside was transformed. Thus a large proportion of English fields, especially in the Midlands, date from the period 1750 to 1850. In Northamptonshire the proportion enclosed at that time was 51%, in Huntingdonshire, Rutland, Bedfordshire, Oxfordshire and the East Riding, 10–50%. In Essex, Somerset and Shropshire it was under 4% because most of the land was already enclosed.

The history of hedges is essentially that of land enclosure. Hooper (1970) has shown that many hedges are older than Parliamentary Enclosure, and there are some Saxon hedges still in existence. Hooper developed a method for dating a hedge showing that its age is proportional to the number of different shrub species it contains. The formula must be calibrated by documentary dating, as the accuracy can be modified by local conditions and multi-species planting. Hedges containing Midland hawthorn (*Crateagus oxycanthoides*) are commoner in areas with old woodlands. Old hedges, which are often farm boundaries, are important to historical research and should be conserved whenever possible.

HEDGE REMOVAL

Many hedges have been removed since the last war, estimates vary from 1,500 miles a year to 14,000 miles a year. The most recent estimates are that of about 600,000 miles of hedges in 1946, some 1% a year has been removed with the rate decreasing in recent years. Removal has been much greater in the arable areas of the south and east particularly where field sizes were small. It is generally accepted that despite removal on a grand scale, there are still 500,000 miles of hedge left in Britain standing on an area of land which exceeds all the country's nature reserves put together. The annual cost of maintenance of these hedges has been estimated at some £2 million a year (Hall, 1978).

The main reason for hedge removal is to increase field size to aid mechanisation and gain flexibility, especially when farms are amalgamated. Hedges are not worth retaining in fields of under 8 ha and 20 ha seems to be the optimum field size. There is some indication of a desire to return to smaller 20 ha fields where large, 40–60 ha fields were created some years ago. Large areas are more difficult to manage where precision is required in crop treatments, and may contain several soil types resulting in uneven maturity and problems with cultivation. Old field boundaries often separated soils requiring different management.

Other major reasons for hedge removal are to avoid maintenance and reduce headlands. Hedges cause shading and uneven ripening of crops and can create frost pockets. They also harbour weeds and pests, although recent work by The Game Conservancy has shown the value of predators which feed on cereal aphids, and which rely on field boundaries as over-wintering sites. The total

length of field boundaries on farmland has decreased considerably since the last war and important insect predator species have declined substantially over the past ten years. Some hedge removal will probably continue, but only 2% of farmers surveyed by the Ministry of Agriculture, Fisheries and Food (MAFF) (1976) intended further hedge removal.

HEDGE MANAGEMENT

If left alone most woody hedge plants such as hawthorn would eventually grow into trees leaving a row of trunks with gaps at ground level. Such a hedge is no longer stock-proof and no longer a hedge. It is necessary to trim hedges from time to time in order to prevent deterioration.

A well maintained hedge is of value to the farmer, landowner and conservationist. Hedges offer shelter to sensitive crops, livestock, game and wildlife; they are an important feature in the farming landscape and a tough and impenetrable barrier to farm livestock and unwanted visitors to the farm.

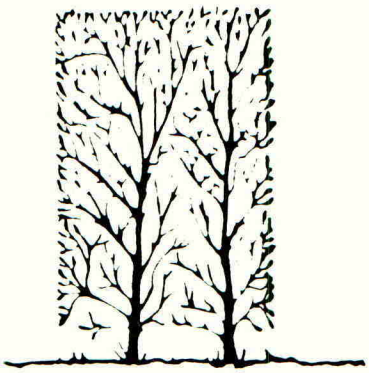
Hedges need regular maintenance and can then remain effective for many years. To achieve this, farms and estates need a long-term hedge management policy and a regular and economical maintenance programme.

When labour was plentiful, trimming hedges and clearing ditches (which often run alongside) was fitted into a slack time when there was less to do on crops, either in the winter or late spring or just before or after corn harvest. Great pride was taken in trimming a hedge neatly.

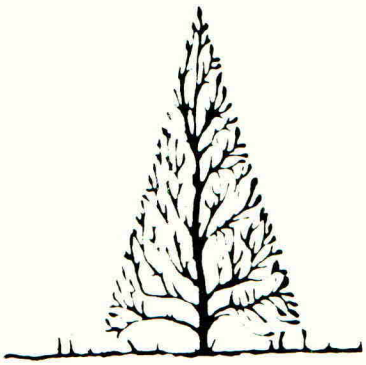
With increased farm mechanisation and only a small, regular farm staff, there is no time to spare to cut hedges by hand and machine maintenance is almost universal. Such machine trimming has reduced the number of hedgerow trees as saplings are difficult to spare if time and care is not taken. Grouping saplings at the ends of hedge runs, or where hedges form field corners, makes it easier to leave them and tagging with coloured plastic helps to draw the tractor driver's attention to the saplings.

Regular trimming of hedges stimulates the growth of side shoots, making the hedge dense and stock-proof. If left, the shade from a mass of side shoots will eventually kill-off new growth from the original plant leaving the centre of the hedge thin and gappy. If trimming is carried out every two or three years, maintenance costs will be reduced and the vigour of the hedge prolonged. Such a hedge provides shelter for game and wildlife.

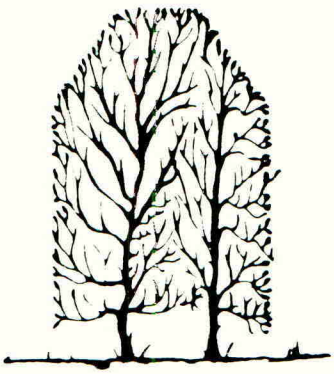
Trimming can be carried out at any time of the year except in May and June, but summer trimming should be avoided as it will disturb nesting birds and autumn trimming will destroy berries and fruit which provide winter food for birds. The best time for trimming is winter or early spring except during periods of hard frost which may damage a newly cut hedge. If hedges are trimmed every two or three years, instead of annually, costs are reduced and hedge plants produce more flowers and berries.



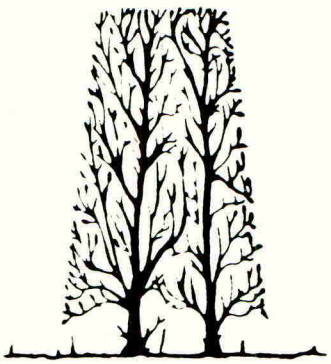
Rectangular or box shaped



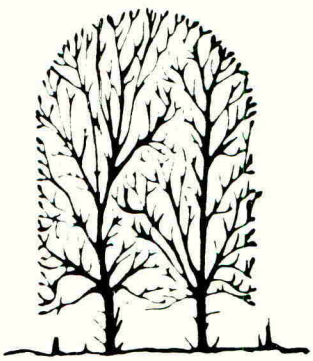
A-shaped



Chamfered



Topped A-shaped



Rounded-for hand trimming

Figure 1. Common profiles for farm hedges.
Reproduced from MAFF Leaflet 762 by permission of The Clerk of Stationery (MAFF, 1980)

There are five common profiles used to shape farm hedges (MAFF, 1980). The rounded profile for hand trimming and the straight-sided for mechanical trimming (see Fig. 1). A useful stock-proof hedge needs to be at least 1.4 m high (about 4½ ft). A height of 1.8 m (6 ft) provides the best shelter for livestock and wildlife.

Machine trimming is carried out in such a way as to produce an effective hedge with the fewest passes of the machine. An "A" shaped hedge cut to a height of 1.8 m offers the greatest advantages: it is the most convenient shape for mechanical trimming; a good windbreak, allowing the wind to pass over and through the hedge with the least turbulence; less easily damaged by heavy falls of snow or cuttings left on the top of the hedge; dense growth at the base ensures that it is stock-proof and provides good cover for wildlife and game birds; and allows the development of hedgerow saplings. There are four types of hedge trimming tools:

1. *The cutter bar* – a tractor-mounted reciprocating cutter suitable for use on hedges in good condition and not designed to deal with heavy growth. It is usually only capable of coping with hedges which are trimmed each year.

2. *The flail cutter* – a tractor-mounted machine designed to deal with heavy growth and widely used for hedge trimming. It chops, chews and mulches the growth on hedges, verges and ditch sides leaving no trimmings to be picked up afterwards. When properly used and correctly maintained, flail cutters leave a neat job, but if they are used on heavy growth they can leave a very unpleasant ragged effect. Severe laceration of stems is often produced which opens the hedge to fungus attacks and die-back. The trimming of heavy stems is best left to a circular saw.

3. *The circular saw* – sometimes referred to as a shape saw, is either tractor-mounted or trailed. It is ideal for re-shaping overgrown hedges or for cutting neglected hedges down to ground level. Circular saws can be used on growth up to 6 in in diameter or they can be fitted with scimitar blades to cut lighter material. Stems over 6 in in diameter should be cut with a power chain saw.

4. *Hand tools* – are only used for hedge laying for sites where making a neat job is more important than speed or cost, or possibly in places where access for machinery is difficult. Where machines are used, handwork will still be needed to cut out rubbish, such as elder or briar, and to trim carefully round promising saplings which may be left to grow to hedgerow trees. Traditional hand tools are the lightweight axe, the billhook, the hedge slasher and the hand saw. Hand held power tools are available for trimming, but are usually more appropriate to the garden than to the farm.

It cannot be too strongly emphasized that all tools, whether hand or mechanical, must be kept sharp and in good condition if the best results are to be achieved. Mechanical hedge trimmers are dangerous if not properly operated and maintained and it is essential that operators should receive instruction and guidance on the maintenance and use of hedge cutting machinery.

ECONOMICS

Pollard *et al.* (1974) and the British Trust for Conservation Volunteers (Anon, 1975), have carried out studies which show that an established hedgerow is more cost effective than a fence. These studies did not fully allow for the cost of hedge maintenance, particularly using specialist cutting machinery. Sturrock & Cathie (1980) showed that the hedgerow was uneconomic compared with alternative forms of fencing. This study compared the cost of establishing a blackthorn hedge with a number of fence options. Using 1979 figures, a post and wire fence would cost £30–£35 for 22 yds; a post and rail fence £100 for the same length, whereas planting, stock-proofing and maintaining a hedge of the same length for ten years was estimated to cost £55. Where rabbits were likely to be a danger to the newly planted hedge, the cost rockets to an alarming £320 for the 22 yds.

There are of course advantages from hedgerows for shooting, wildlife conservation or as shelter for stock, and these are recognised as valuable functions in the farming community. It is, however, difficult to set a notional price on these. The Sturrock & Cathie study also shows that the cost of laying an established hawthorn hedge, compared with replacing it with a fence, does not give so large a difference as to favour the fence. It is reasonable to expect that the hedgerow will remain, especially considering the advantages for wildlife (including game). The other options for a field boundary are not as costly as the establishment of hedgerows, and the facts suggest that hedgerows judged as field boundaries are not economical under today's conditions.

Wood (1982) reporting work on willow hedges (*Salix* hybrids) at the Arthur Rickwood Experimental Husbandry Farm states that loss of revenue from the uncropped area occupied by hedges and the cost of establishment and annual trimming still leaves a cash benefit in favour of them, provided the rotation includes sensitive crops such as sugar beet, onions or carrots, where wind damage can be significant.

PUBLIC REACTION

The public prefer to see old, rather unkempt hedges with flowers and berries in due season, rather than a well-trimmed small hedge, and they do not like to see coppicing. There is also concern about the use of flail cutters which leaves an unsightly hedge immediately after the passage of the machine and, indeed, for some months after. There has also been much controversy over the hedge trimmings which are left about in lanes and roads which can cause punctures, especially to bicycle tyres.

Farmers should be encouraged to keep field sizes to around 20 hectares and to maintain and care for farm boundary hedges, which are excellent barriers to trespass. Hedge maintenance should be carried out on a regular, two to three

year cycle with proper regard for nesting birds and to the berries and fruit for the autumn and the winter.

Hedges are of little use to arable farmers and frequently hinder them, but they are useful where stock-proof hedges surround conveniently sized pastures and for high value horticultural crops. They are important as landscape features and for historical research, and may reduce the general windiness of the climate. Wildlife find hedges increasingly important for food and shelter as other habitats are removed. It is worthwhile, therefore making an effort to identify, map and conserve ecologically rich and old hedges, and those vital to the landscape. Older hedges which form farm boundaries can be retained with minimum hinderance to agriculture. Conservation of hedges which have no agricultural function involves expense and where these are of particular importance historically, or for conservation reasons, then there may be a case for compensating some farmers from public funds for any inconvenience caused through maintaining the hedge.

RESEARCH

Further research should include work on hedge dating outside the south-east of England and studies of the effect of hedges on windiness in Britain, comparing open and hedged regions. Work on the importance of hedgerow fruits to wildlife and studies of predatory mammals in hedges would also be valuable. More information is needed about different management methods and the value of these for wildlife in the long-term; and about the long-term effects of different maintenance techniques on the hedges, and the way these influence its effectiveness as a barrier. Further research is needed on the possible value of hedges and hedge bottoms as a habitat for predators of the insect pests of cereals.

It would seem too that information is required on the operation and maintenance of hedge cutting machines, particularly their rate of work. Some machines may not be operated correctly with consequent damage to hedges and inefficient working.

SCRUB

Scrub may be classified as the woody growth of shrubs and plants consisting mainly of hawthorn, bramble, *Prunus* and other species which occurs where grazing animals are excluded from grassland. Another definition of scrub would cover the similar growth which occurs following the felling of woodland, either clear felling or partial felling, where bringing in light encourages the growth of scrub. Some forms of scrub (e.g. brambles) grow best where there is no direct light. Scrub, like any other type of vegetation, is not a fixed state,

but a transition between grazed grassland and woodland, and left unmanaged scrub will move towards whatever type of natural woodland the area will support. It is often stabilised due to grazing by either farmstock or rabbits, and only becomes troublesome when it is invaded by weed growth due to changes in stocking or the clearance of rabbits. Gorse (*Ulex spp.*), bramble (*Rubus spp.*) and bracken (*Pteridium sp.*) can quickly invade large areas and render them impenetrable. The best known example of scrub development is the change in chalk grassland when sheep grazing declined for economic reasons and rabbits succumbed to myxomatosis. Large areas rapidly became covered in hawthorn and bramble, much to the annoyance of the public who could no longer enjoy the use of them.

Scrub can occur in any part of the UK where conditions for its development are suitable. Neglected, under-grazed fields will be invaded from the hedgerows by seedlings which, no longer cut or grazed off, quickly become established as isolated bushes. Wasteland awaiting development, disused railway lines and wide road verges will all revert to scrub. Wet scrub can also form in shallow ponds or depressions or areas flooded as a result of impeded drainage following road or railway construction work. Even fen and marsh can, without management, give way to scrub and carr which will eventually move to drier woodland as the peat accumulates.

It is difficult to find any reliable references to the total area of scrub in the country, it has been suggested that it could amount to some three hundred thousand ha. The Forestry Commission carried out a census of woodland in 1951 and classified 50% as high forest, 10% as coppice and 15% as scrub. Later writers suggest that most of the coppice should be transferred to scrub. Way (1977), states that there are more than 200,000 ha of roadside habitat including hedges, ditches and scrub in Britain, half of which is managed grassland.

Without grazing there would be very little grassland in Britain, only scrub and forest. The best documented example of the transition is probably Broadbalk field at Rothamsted Experimental Station where, in the 1870s, part of a wheat field was shut-off and left. The records show how this moved from wheat to a mixture of wheat and weeds, scrub and to what is now an established oak forest.

Scrub can be of great value to wildlife – many birds make use of it for nesting and cover and it provides shelter for small mammals. If it is not managed it eventually becomes dense, which reduces its value to wildlife, and there is no grazing for rabbits, deer, etc. between the bushes. Scrub grassland can be seen to reflect different needs. The conservationist wishes to see the perpetuation of those areas of grassland which provide good examples of their type and of those which harbour populations of different species which, because of their rarity, attractiveness, or scientific value, provide some particular interest. A high stocking density will maintain a close cropped, herb-rich turf of interest to the botanist. The entomologist will favour a lower grazing pressure, allowing taller grassland and more cover for invertebrate fauna.

The ornithologist only wishes to limit grazing to allow scrub to encroach and scattered bushes to develop to enhance birdlife. This process can be seen on the chalk downlands where, over time, free-ranging sheep have developed a soft, herb-rich downland sward. The withdrawal of grazing, due to lack of demand for the type of sheep concerned and the control of rabbits by myxomatosis, brought about a change to coarse grasses with the number of plant species density reduced. There was undoubtedly more insect life, but gradually woody species invade and survive so that the area turns into scrub and eventually, forest.

The word "scrub" is often used disparagingly, and these areas are not recognised as embryonic woods. Scrub is, indeed, a constituent of woodland under normal circumstances.

The age structure of scrub is of considerable importance, especially where there are areas of dense scrub, newly trimmed lengths of hedges, saplings and mature trees.

Epping Forest is another area which shows the effects of failing to understand the need for management. The Forest was transferred to the Corporation of the City of London and the conservators charged in 1878 to preserve the "natural aspect" of the Forest and to protect the trees etc. At that time it was not understood how much this depended on management. Pollarding was prohibited and grazing run down. The natural features that it was desired to keep have now declined. Pollard specimens have grown and shade out the woodland flowers and shrubs; lack of grazing has caused the loss of heather and over-running by scrub woodland.

Once scrub has been established the build-up of fertility, especially by soil nitrogen-fixing species such as broom (*Sarothamnus scoparius*) and gorse (*Ulex spp.*), may render the restoration of short diverse swards almost impossible, even if the scrub is removed.

Bramble (*Rubus spp.*) occupies a special place as it has a wide range, growing on good soils and also on thin, acid soils. Brambles, or blackberries, are virtually the sole spontaneous scrubby species occurring with any frequency.

Brambles are long-enduring in the places in which they occur, they are not easily eradicated, no-one wants to remove them for commercial or ornamental purposes. Their prickliness saves them from casual trampling and bruising. They spread vegetatively in a most robust and vigorous fashion by means of off-sets formed at the tips of the main stem and its branches. Tip-rooting seems to be the principal form of propogation and accounts for the continuous distribution of individual bramble species. Seedlings are produced as well, often in quantities especially where birds perch with regularity, but they cannot stand much sunshine and are subject to the many dangers that are the fate of seedlings generally. It would seem that seeds are not the primary mode of spread, although bird dispersal is of course essential for the colonising of new areas. Tip-rooting is the way in which brambles build up colonies once the initial immigration has taken place.

The bramble is so successful that it is surprising that it does not cover the countryside to a depth of several feet. Fortunately rabbits and other grazing animals seem to keep new plants from developing. Rabbits certainly feed on the tender stem shoots and the seedlings, keeping the plants effectively in check.

Brambles are an effective barrier to the public – they are not enjoyed by them except for the autumn pursuit of "blackberrying".

Brambles harbour rabbits, but they are an excellent means of keeping the bottom of woods warm in the winter for game and wildlife.

MANAGEMENT

Brambles can be controlled by cutting when young in order to prevent establishment, and cutting or burning the old bushes in rotation. In woodland a flail or swipe can be used to keep brambles under control in rides, cutting twice a year and avoiding the nesting season.

2,4,5-T is an excellent brushwood killer, very effective against brambles and nettles, although its use may raise problems in some areas. It is quite safe if used correctly. Spraying should be kept to a minimum and only applied as directed sprays to individual plants.

Scrub does need to be controlled, and this is best done on a rotational basis so leaving a range of habitats. Some will be cleared as land is developed or if there is pressure to use land more intensively, as in the uplands. In upland areas the fell wall marks the limit of enclosure, and this limit has shifted according to economic pressures, probably reaching its highest level some time in the mid-19th century, followed by a period during the 1930s when land was abandoned. During this time, scrub encroached below the fell wall, usually bracken, followed by woody scrub such as hawthorn and gorse. Where land is open for access by the public, scrub will require management, otherwise the whole area will become inaccessible. Cutting and burning would appear to be the most successful method – taking care to avoid the nesting season and adopting a rotation so that a varied habitat is left.

REFERENCES

ANON. (1975) *Hedging – a practical conservation handbook.* Reading: British Trust for Conservation Volunteers.

GREEN, B. H. (1981) *Countryside Conservation.* London: George Allen & Unwin.

HALL, J. (1978) Management of hedges and hedgerows. *Big Farm Management* 2, 29–32.

HOOPER, M. D. (1970) Dating hedges, *Area* 4, 63–65.

MELLANBY, K. (1981) *Farming and wildlife.* London: Collins.

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD (1976) *Wildlife conservation in semi-natural habitats on farms. A survey of farmer attitudes in England and Wales.* London: HMSO.

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD (1980) Managing farm hedges. *MAFF Leaflet 762.* London: HMSO.

POLLARD, E.; HOOPER, M. D.; MOORE, N. W. (1974) *Hedges.* London: Collins.

STURROCK, F. G.; CATHIE, J. (1980) *Farm modernisation and the countryside.* Cambridge: University of Cambridge Press.

WOOD, M. B. (1982) *Arthur Rickwood Experimental Husbandry Farm review.* London: HMSO.

WAY, J. M. (1977) Roadside verges and conservation in Britain: a review. *Biological Conservation* 12, 65–74.

DISCUSSION FOR MR CARTER

Mr Fryer I should like to endorse the need for better guidance to be available to farmers on the management of hedges. Particularly in respect to the management of herbaceous plants growing in the hedge bottoms, and around the borders of fields. Since 1976, when sterile brome first became a serious weed in winter cereals, many farmers have taken to spraying hedge-bottom vegetation with herbicides in an endeavour to keep it, and other weeds, from invading the field. They generally have little idea of what they are doing ecologically; by opening up the vegetation cover and providing fresh sites for seedling establishment they often do more harm than good. Research is needed to provide soundly based advice. The objective should be to develop management strategies for maintaining the vegetation, firstly to minimise weed invasion, secondly to provide a stable and diverse community and a favourable habitat for wildlife. I hope that participants who can help us to define these objectives more precisely will be willing to let us have the benefit of their experience.

Mr Carter (Speaker) In arable situations, rather than spray hedge bottoms, the long term effects of which can be quite disastrous for the habitat and for wildlife, the best thing to do is to have a strip at the edge of the field, between the crop and the hedge proper, which is kept bare by cultivation, probably best by rotovating. This is an excellent drying-out place for pheasants and other birds, and stops any rubbish (weeds) getting out from the hedge bottom into the field itself, whilst the loss of land is minimal.

I agree also that we should have a greater co-ordination of the expertise that is available, and perhaps the Weed Research Organisation can help in bringing people together. I should welcome more work on this.

Mr Barber (Chairman) I expect that you would agree that a mown grass strip would be an acceptable alternative to a rotovated strip (Mr Carter – Yes), because I know of a large and very successful farming partnership where they do just that. Each field has a mown grass strip around it, and the hedges are well managed but the hedge bottoms are never touched. Then round the cultivated field itself there's one boom's width which is never sprayed, so that there is a certain amount of annual weed there and associated insects. All in all there are six or seven different habitats represented within the field boundary, and that's quite a remarkable development.

Mr Burdekin The figure in the paper of 3 million ha of scrub is rather high, and 300,000 ha, based on a recent Forestry Commission survey, would be nearer the mark. Reliable figures from this survey will soon be published under the title of *'The 1982 Census of Trees in Woodland and non-Woodland Areas'.* In this context we are probably defining scrub as

embryonic woodland. (Mr Carter accepted Mr Burdekin's figure of 300,000 ha which is the figure now given in the paper – Ed.)

Mr Cave Is there any use for growth retardants as a substitute for cutting hedges, or to supplement cutting?

Mr Carter (Speaker) I have no experience of that.

RESEARCH

Research on Chemical Methods of Vegetation Control

T. O. Robson
Agricultural Research Council
Weed Research Organization

INTRODUCTION

The great majority of herbicides have been developed for use in agriculture and horticulture and as such are designed to remove unwanted plants from within a crop. The crop is usually a mono-culture and all non-crop plants growing within it are considered weeds. An exception to this is established mixed pastures in which a number of different species contribute to the production of fodder. But even here there is a tendency to attempt to manage the sward for a high percentage of rye grass, which is considered the most productive of our British grasses. Another fairly large group of herbicides has been produced as total weed killers to remove all vegetation and prevent plant growth in areas where, for ornamental or some other reason, no vegetation is to be permitted. But there have been very few, if any, herbicides developed specifically for the management of natural and semi-natural vegetation.

The reasons for the concentration of effort on the development of chemicals for the agricultural, horticultural industries and for total weed control are of course, mainly economic. It is in these areas that the market exists and it is in these areas that the effectiveness of herbicides can be demonstrated and appreciated most readily. The development of a new herbicide for these purposes, although involving a lengthy R & D programme and costing a great deal of money, has an objective that is comparatively straight forward. Basically they have to kill weeds without endangering the crop, the operators, or the consumers. In non-crop situations wildlife in its widest sense becomes prominent and objectives become difficult to define. A natural plant community supports a wide range of interdependent plants and animals, the proportions of which are changing all the time altering its structure and composition, so that it can be defined only in rather nebulous terms. The effects of herbicides will be both direct, mainly phytotoxic, and indirect, through the disruption of the habitat. It is little wonder, therefore, that there are so few instances of herbicides being developed specifically for these uses.

OBJECTIVES OF RESEARCH AND DEVELOPMENT

In the development of a new chemical as a herbicide in a crop situation an assessment of its value is based on a high degree of specific toxicity to some plant species (weeds) and a high degree of tolerance by other plant species (crops). It may be possible to exploit the same properties of selection in semi-natural and natural vegetation where similar weed encroachment occurs. For example, nettles and thistles may invade amenity grass swards in picnic areas and like situations and suitable recommendations can be obtained directly from experience on pastures. Similarly, the encroachment of woody species may be arrested by herbicides developed for agriculture and forestry, although in this case new application techniques may be needed if overall spraying is not appropriate. There are numerous examples where chemical techniques have been adopted successfully in non-farming areas such as country parks, nature reserves, and for roadside maintenance. But this use is based on established concepts of selective weed control in crops and although it is of proven value, it does not exploit anything like the whole potential of these chemicals.

In the case of water weeds, research with herbicides started on much the same basis, with the development of a new use for an established chemical, because at that time only a few clearly identifiable troublesome plants were deemed to have the highest priority (Robson, 1967). These were emergent reed-like plants such as the common reed (*Phragmites communis*) and bullrush (*Typha latifolia*) whose foliage it was possible to spray in virtually the same way as one sprayed dry land plants; albeit the application equipment often had to be modified. When it came to considering the use of chemicals against submerged plants it was immediately apparent that anything that was put into the water would affect a complex biological system consisting of inter-related plant and animal communities. The objective of water weed control in its simplest form is to achieve a level of control of troublesome plants that will permit the functioning and use of the waterbody. This approach in land drainage systems stimulated the early concept of total weed control and the development of herbicides such as diquat, dichlobenil, chlorthiamid and terbutryne. In some instances the control of all plant growth for at least part of the growing period is still of paramount importance, e.g. land drainage channels, and any disruption of the biological system may have to be disregarded. However, in the course of the development of these aquatic herbicides their impact on the invertebrate and particularly fish populations was monitored. While there was a reduction in plant-dependent species, the zooplankton and bottom living organisms continued to thrive and to date there has been no evidence of serious adverse effects on coarse fish populations, apart from occasional short-term deoxygenation. But, it has been appreciated all along that in the majority of cases the removal of all plant growth is undesirable and frequently inadvisable.

The management of natural vegetation in both fresh water and on dry land requires a different approach from that of conventional weed control in crops

and on industrial areas. In the majority of cases it is difficult to define the objectives in precise and detailed biological terms. The vegetation is a diverse and dynamic community of plants which supports an equally changeable animal population, and except where there is some particular species which attracts special attention in a nature reserve or SSSI, definitions are in vague terms such as 'preserve wildlife habitats'. In practice most of the objectives of managers are to avoid excessive untidy growth and retain roughly the same botanical composition. They are in essence the traditional objectives of mowing and grazing regimes applied to meet the needs of the users e.g. short swards for picnics, weed-free water for fishing, and no impedance to flow in land drainage channels. Little or no thought was given to wildlife preservation unless it directly affected the use to which the land or water was to be put. Now that the dangers to wildlife are becoming more acute and more fully appreciated and economic pressures are stimulating the search for new management techniques, the preservation of appropriate habitats must be included in management plans for natural and semi-natural vegetation. Chemicals can offer managers a flexible set of tools by way of their selective properties and ease of application.

RELEVANT PROPERTIES OF AGROCHEMICALS

Perhaps the one most important property of modern herbicides from a biological point of view is their selectivity. The advantage to farming of the original hormone weed killers, which removed broad leaved weeds from cereals, has been extended and refined to the point where weed grasses can be eliminated from graminaceous crops and even from mixed pastures. The susceptibilities of most of the non-agricultural plants found in natural and semi-natural vegetation have not yet been assessed and much of the potential value of herbicides for their management rests on these properties.

The inherent selectivity of the herbicide is not the only way to achieve selective control. Exploiting other properties, for instance, a low solubility in water to retain the active ingredient in the top layers of the soil above the root zone of the plants that are to be preserved (e.g. simazine in blackcurrants) is another approach. 'Contact' herbicides, such as diquat and paraquat which act on the green tissue of plants and are inactivated by soil, may be sprayed to kill weed seedlings immediately after germination or to remove more fully developed annual plants from perennial species which readily regrow.

An obvious way of achieving selective control is by applying the herbicide only to those plants you wish to remove. Directed spraying with shields to protect the plants to be retained has been used, particularly in forestry, for some years. More recently selective application exploiting height differentials has received attention in some agricultural situations, e.g. docks in pasture and wild annual beet in sugar beet. The herbicide is smeared onto the taller plants above the foliage of the crop and a number of machines are now available to do this. Selective application in water has recently been developed successfully

using a viscous carrier for diquat that sticks to the foliage of the weeds and, as it releases the herbicide, creates a lethal concentration in close proximity to the plant (Barrett, 1978).

As plants age so they usually become less susceptible to herbicides and this can help enhance selectivity. Ultimately the onset and duration of dormancy as seeds or vegetative propagules may offer opportunities to preserve some species at the expense of others. These possibilities are not much used in agriculture but have interesting potential in natural and semi-natural vegetation.

Growth regulating chemicals that change the growing habits of plants are used to a limited extent in practice to suppress grasses and replace mowing. Some compounds have been developed to strengthen the straw in cereal crops to prevent lodging and others effectively inhibit flowering and apparently improve the nutritive value of pastures. These compounds also have applications in amenity and other non-crop situations.

CURRENT RESEARCH WITH HERBICIDES

Current research with herbicides on terrestrial natural and semi-natural vegetation is limited in both quantity and scope. There are two projects at the Institute of Terrestrial Ecology, Monkswood, financed by the Nature Conservancy Council, another at Cannock Chase financed by the Countryside Commission, and a third at the Weed Research Organization, again financed by the Countryside Commission. There are also projects on the management of pastures, forest plantations and the reclamation of derelict land which do sometimes include relevant work.

Grass swards

The Countryside Commission's project based at the Weed Research Organization is to assess the feasibility of using chemicals for the management of rural amenity areas. A range of herbicides has been tested for the control of coarse grasses, including Yorkshire fog (*Holcus lanatus*) and false oat grass (*Arrhenatherum elatius*) in natural and semi-natural grasslands. Part of the programme is also concerned with the control of invasive woody species into grassland and heather. The three year contract under which this work has been done will end shortly and the results will then be published. Preliminary indications are that Yorkshire fog can be removed by asulam or linuron and that single applications of the two herbicides dalapon or paraquat to a mixed sward in the autumn reduces grass bulk the following year (Fig. 1), but on their own they cannot replace mowing entirely. Dalapon also tends to encourage common wild flowers but on some sites undesirable species, such as nettles and thistles, may come in and dominate.

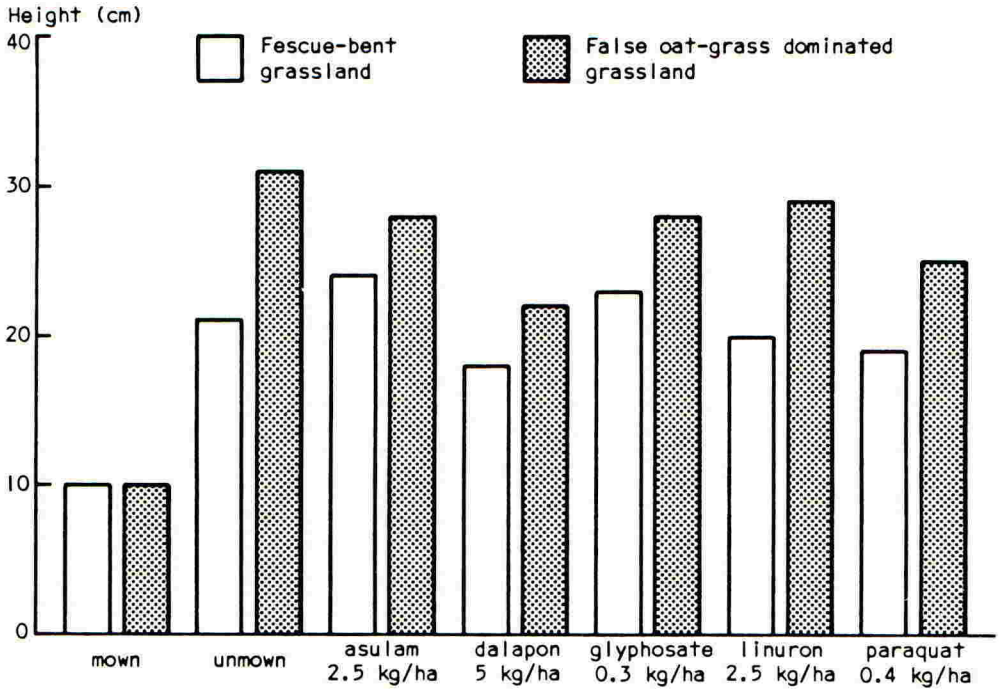


Figure 1. Sward heights of two grasslands measured in June, after herbicide applications the previous autumn (Marshall, 1982).

Heather

Attempts to encourage the establishment of heather by reducing competition from other plants with herbicides is being studied by the Institute of Terrestrial Ecology (ITE), and in the Countryside Commission project on Cannock Chase. In a series of field experiments ITE have found that the biggest increase in germination of heather occurred when the existing vegetation was killed with the herbicide paraquat (Natural Environmental Research Council Report 1979–1980, pp. 89–90). Herbicides are also included in the Countryside Commission project on Cannock Chase in Staffordshire which is aimed at restoring heather to areas damaged by fire.

Tree encroachment

Current work with herbicides on woody species is examining a number of herbicides for the removal of tree species from heathland and grassland. The results of a range of herbicides on hawthorn in chalk grassland are shown in

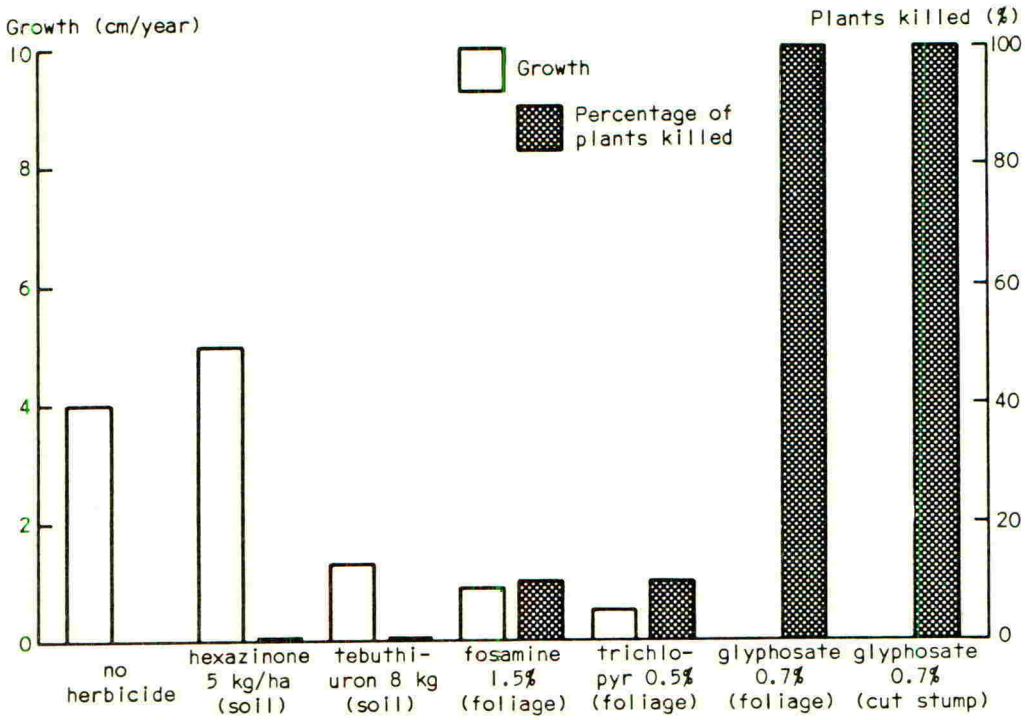


Figure 2. The effect of several herbicides on hawthorn bushes, measured by height increase after 12 months and number of bushes totally killed (Marshall, 1982).

Fig. 2 (Marshall, 1982). Although they did not kill the plants, fosamine ammonium and trychlopyr prevented foliage developing the following season, and tebuthiuron applied to the soil stopped the hawthorn making much growth. Glyphosate, both applied to the foliage and to the cut stump successfully killed the plants, although it did also damage some of the herbage around the sprayed bushes. This work seems to indicate that suitable herbicides are available for controlling woody plants but improved methods of application to ensure their selective removal from both heather and grassland are needed.

The ITE project at Monks Wood is also using known arboricides against birch encroachment in heathland.

Freshwater

Current research on herbicides for the control of weeds in or near fresh water is primarily concerned with devising and developing new ways of using them. Techniques which are more selective than those recommended when the herbicides were originally cleared for use in water under the Pesticides Safety

Precautions Scheme are being sought. The reasons for this approach are firstly to avoid any risk of possible side effects such as deoxygenation, which can result from the breakdown of large quantities of organic matter, or the destruction of the habitat of other important aquatic organisms and associated birds; and secondly to give the manager an opportunity to regulate the cost by clearing only a part of the water at a time.

The principles behind this work are concerned with both the uptake and activity of the herbicide and also the placement of the active ingredient onto the plant at the site of uptake. So far, two chemicals have received most attention – dichlobenil and diquat. Dichlobenil is absorbed by the roots of terrestrial plants and when applied in a granular form to the bottom of lakes strongly rooted submerged plants, such as mare's tail (*Hippuris vulgaris*) and milfoil (*Myriophyllum spicatum*), can be removed in discrete patches from beds of submerged weeds. Although the herbicide is dissolved the concentration in solution is insufficient to kill any of the adjacent untreated plants. In contrast diquat is taken up by the green foliage and is inactivated by the mud of the bottom of a lake or channel and so selective control has been achieved by the use of a viscous carrier, which sticks to the foliage of the submerged plants and releases the herbicide in close proximity to the absorptive tissues. A new formulation developed at the Weed Research Organization uses alginate as the viscous carrier and this is now available on the market.

A need which has not yet been met in the management of freshwater systems is for a practical method of controlling filamentous algae without destroying the vascular plants. The only algicide available at present is terbutryne but it also kills most of the higher plants and results in total weed control. The chances of commercial interest in the development of new algicides have diminished because of the comparatively small market and the increasing costs of research and development. Any development of a new algicide can therefore only be expected as a minor use of a chemical developed for some other major market.

CURRENT RESEARCH WITH GROWTH RETARDANTS

Growth retardants are chemicals which do not kill the plants they are applied to but in some way stop elongation or at least reduce the rate at which plants grow. The commonest example in this country is maleic hydrazide which has been used for many years to reduce the height of coarse grasses in ungrazed swards such as roadside verges. The best example of the long-term effects of annual applications has been reported by Willis (1972) from the results of his work near Bibury over the last 25 years. Repeated applications have eliminated the coarse species of grass and encouraged the shorter growing fescues. For over 10 years this chemical has also been used regularly to control grasses on the sloping banks of some land drainage ditches in the Fens.

Maleic hydrazide (MH) has not always been entirely reliable and at the Weed Research Organization it has been compared with other, newer growth retardants as possible alternatives to mowing. Mefluidide appears to be better than maleic hydrazide in that it acts more quickly and is more reliable. In both cases they perform best when applied in the spring, when subsequent grass growth can be retarded for a period of up to ten weeks. Of perhaps more significance in amenity areas where appearance of the sward is important, is that both have the capacity to delay grasses flowering and the untidiness associated with it. A summary of the main results taken from Marshall (1982) are given in Table 1. The third retardant PP333 was not considered to be as effective as the other two because it appeared to have a more suppressive effect on the more desirable fine grasses than on coarse species, and did not suppress flowering.

Table 3
Summary of the attributes of three growth retardants (Marshall, 1982).

Chemical	Mode of uptake	Speed of effect	Period of growth suppression (weeks)	Ability to suppress flowering	Retardation of fine grasses	Retardation of coarse grasses
MH	Foliar	+	8–10	+	+	++
mefluidide	Foliar	+++	10	++	+	++
PP333	Soil	+ (dependant on rainfall)	>14	–	++	±

Grass retardants have also been the subject of experimentation in cider apple orchards at the Long Ashton Research Station, and for increasing sward species diversity at Lanchester Polytechnic. Otherwise growth retardants appear to be attracting little in the way of research.

FUTURE RESEARCH POSSIBILITIES

The general objective of management of most natural and semi-natural vegetation is to change either the botanical composition of the seasonal growth pattern of the plant community, by holding back normal plant succession or delaying natural summer development. No single universal answer is likely to achieve the objectives, and so the most appropriate will have to be chosen from a range of available techniques including both chemical and non-chemical operations. Further research will widen the range of options available and our knowledge of how to use them. The following is a list of some of the main aspects that occur to me of chemical use that could contribute to increasing the range of options through further research.

Selectivity

1. The inherent susceptibility of non-agricultural plant species to agricultural herbicides chosen as the most likely to show selectivity in natural plant communities needs to be studied in a programme covering:
   a) A range of doses of selected herbicides applied at different growth stages of the plant e.g.
      i) susceptibility generally diminishes as plants mature;
      ii) translocation of herbicides within plants is enhanced at certain growth stages; e.g. post-flowering application to many perennial grasses ensures greatest movement of dalapon to the rhizomes and subsequent control of regrowth.
   b) Sub-lethal doses for the retardation of growth rather than phytotoxity.
   c) Timing herbicide application to exploit phenological differences in the plant community e.g.
      i) early spring applications to make use of differences in time of establishment i.e. killing annual seedlings amongst perennials or defoliating perennials to encourage annual seedlings.
      ii) differences in the onset of senescence afford an opportunity to remove certain species in favour of others.
2. The selective application of herbicides has already been referred to and is a comparatively new concept which must continue to receive attention so that:
   a) Sensors which distinguish differences between species other than obvious physical differences of height, may be identified and developed e.g. reflectance sensors selecting an appropriate range of radiation wave lengths.
   b) Specific formulations and preparations are found to provide far more precision in the field e.g.
      i) sticky formulations for "weedwipers"
      ii) individually impregnated bamboo pegs (Japanese picloram 'matches').
      iii) encapsulation for placement and slow release.
      iv) carriers to provide greater control over placement in water.

Effect on plant competition

1. The effects of shading within a community may be modified by altering the height/density relationship between species e.g.
   a) Opening the sward to encourage seedling growth either with:
      i) defoliants
      ii) herbicides to create bare patches
   b) Reducing the height of taller species with growth retardants.

c) Encouraging alternative dominant plants by holding back competitive species at an early stage.

2. The degree of subsurface spread and root competition may be changed by growth regulating substances e.g.
   a) Root development, morphology and distribution can be changed by herbicides and competitiveness for moisture and nutrients altered in terrestrial plants; and their adequacy for anchorage modified in submerged aquatic species.
   b) The development and extension of rhizomes might be regulated by chemicals e.g.
      i) foreshortening or total inhibition of growth
      ii) interference with physiological processes such as geotropism.
3. Inhibiting or delaying flowering and interfering with seed production and seed dormancy could alter the competitiveness of different species at the seedling stage.

Effect on environmental factors

1. The addition of fertilizers and lime for the enhancement of plant growth is well established but in non-agricultural areas establishing and maintaining a low level of fertility may be of greater importance, e.g.
   a) The precipitation of dissolved plant nutrients in lakes to prevent algal growth
   b) The immobilization of plant nutrients and/or the lowering of pH to encourage species rich swards with low maintenance requirements on non-agricultural sites.
2. The natural plant succession on areas of low fertility may be slowed by selective removal of nitrogen fixing plant species or the inhibition of rhizobia.

This list is not comprehensive but it does indicate the wide variety of ways in which chemicals could be developed as tools for the management of mixed vegetation. Whether any development does take place depends primarily on the provision of finance and facilities for research and development. Trends in the agrochemical industry appear to be towards an increasing interest in growth regulating substances which could be of considerable value and interest in the management of natural and semi-natural vegetation. But any new materials will be aimed at the agricultural and horticultural markets and their development for use in other situations will depend on either the recognition by industry of a sizeable potential market or the provision of funds for research from some other source. Until managers are persuaded of the efficacy and safety of new chemical techniques no market will develop, and until new techniques have been developed and demonstrated managers will not be persuaded of their benefits.

It is clear that little progress will be possible until some national body of users accepts responsibility for promoting research and development, not only of chemical methods of management but also of other cultural techniques together with ecological studies on which effective management plans must be based. Finance and advice is frequently available for the planting of trees, the reclamation of 'eyesores' and the planning and establishment of public amenity areas, but, as demonstrated by the paucity of current research, provision for the development of efficient, cost effective, modern methods for their maintenance and for that of our existing natural and semi-natural plant communities is sadly lacking and requires to be given much greater consideration, and a higher priority, if these assets are to survive and avoid the consequences of neglect.

REFERENCES

BARRETT, P. R. F. (1978) Some studies on the use of alginates for the placement and controlled release of diquat on submerged aquatic plants. *Pesticide Science* 9, 425–433.

EVANS, D. M. (1980) Tree stump applications of Roundup. *Proceedings Weed Control in Forestry Conference.* Association of Applied Biologists, 133–137.

GORDON JONES, R.; GLYN JONES, R. (1980) Scrub control with fosamine ammonium (Krenite). *Proceedings Weed Control in Forestry Conference.* Association of Applied Biologists, 139–145.

MARSHALL, E. J. P. (1982) Managing rural amenity sites with chemicals. *Ninth Report 1980–81, Agricultural Research Council, Weed Research Organization,* 71–77.

ROBSON, T. O. (1967) A survey of the problem of aquatic weed control in England and Wales. *Agricultural Research Council, Weed Research Organization Technical Report No. 5.*

WILLIS, A. J. (1972) Long-term ecological changes in sward composition following application of maleic hydrazide and 2,4–D. *Proceedings 11th British Weed Control Conference,* 360–367.

DISCUSSION FOR MR ROBSON

Mr Shaw (Chairman) The case if not for more environmental data, at least for a more systematic approach to existing data has been well made at this meeting. A second theme has certainly been the need to deepen our understanding of the nature and mechanisms of ecological changes, and of the influence of social policies on these changes. These are both arguments which point up the need for more research of the kind described in these two papers today (see also Dr Hooper's paper.).

Dr Holdgate Ways have been illustrated in which new herbicides could have a valuable role in managing vegetation. But yesterday we were told that unless the market was large, the costs of development (including the very stringent toxicological screening processes) could be prohibitive. Will this not tend to inhibit the introduction of some of the ideas described to us – especially those tailored to rather specific problems and treatments?

Mr Robson (Speaker) There is particularly a problem in developing herbicides for use in fresh waters, where there are hazards of wider effects on the environment than just to the target species, and where additional tests have to be done. In the general terrestrial situation, development and testing for the principal agricultural and horticultural markets apply more directly, and the further costs of development for use in non-crop areas need not be anything like as great as one fears.

Mr Small How can one overcome the prejudice of the layman against the use of herbicides?

Mr Robson (Speaker) This is a very difficult problem which we (Weed Research Organisation) have come across in many situations. One way to avoid concern is to treat vegetation at a time of the year when natural senescence is about to occur, so that the effects of applying paraquat, for instance, are less obvious. In general, my experience is that the professional managers of bodies responsible for management of terrestrial and aquatic vegetation are cautious, but not so cautious that they will not use herbicides at all. When herbicides are used, they are generally used carefully according to the recommendations. I don't know of any incidents when they have caused problems.

The only way that they will become more generally accepted, will be by their safe use and proof in the field that they do not have any adverse effects.

Mr Stephens There is a need to educate the public even more on the safety of pesticides, to counteract the misinformation about the hazards often put out by the media. Another problem though is the need to dress up like spacemen in protective clothing to comply with the Health and Safety regulations. Naturally the public will be concerned in a public place if they see someone dressed up like this, and will assume that he is applying something which is extremely hazardous. This is a problem in amenity areas that has not been tackled.

Mr Robson (Speaker) This is a real problem, but we are all governed by the Health and Safety at Work Act. Some formulations of herbicides are being produced to do away with spraying, and for which we probably would not have to wear much more protective clothing than a pair of gloves.

Mr Morrison The public aversion to the use of herbicides in public places is surprising in the light of the statistic in the paper that £5million is spent annually on herbicides for private gardens. The problem is partly one of ignorance, and should be overcome by education.

Mr Spencer-Jones Public suspicion about pesticides is not helped by Television documentaries on topics such as Agent Orange in Vietnam; lung cancer due to asbestos; respiratory effects due to cotton dust and so on, all of which are equated in the public mind with possible hazards due to pesticides. But the problem is in the eye of the beholder. For instance in Holland recently public resistance to the use of a particular herbicide in amenity areas was reduced by changing from a spray to a granular formulation, which the public then believed to be a fertiliser and so 'safe'.

Dr T. W. Wright Whilst there is a problem about safety, there is also public reaction to indiscriminate use of herbicides and the creation of brown deserts. As the use of herbicides becomes more sophisticated, and more selective, the easier it will be for the public to accept them; the use of asulam for bracken control quoted by Mr Robson earlier on is a good example.

On the question of "dressing-up", the use of such application techniques as the Weed Wiper, and the Micron Herbi ULV (ultra low volume) are two methods that can be used that do not require spacemen (see Mr Stephen's comments above).

Mr Gilmour The sophisticated use of chemicals means not only the education of the public, but also education and training of the operators, and of reaching agreements with the Unions. All this increases costs, and militates against the use of these – and other – sophisticated maintenance techniques.

Mr Beckett It might be that with greater operator training, and possibly the granting, or introduction, of licences, that there could be a great improvement in the public acceptance of agro-chemicals. It may come about that the European Economic Community could insist on the licensing of operators in a way that in practice is not the most suitable for UK chemical users, or indeed for European users at large. If this were likely we should perhaps be looking at the introduction of our own licensing arrangements.

Mr Shaw (Chairman) Are you satisfied in the chemical industry generally that everything is being done to ensure that arrangements for training are adequate? This is clearly an area that falls between the private sector and the public authorities.

Mr Beckett I am myself an instructor on the application side for the Agricultural Training Board. We are endeavouring to increase the training of operators and the syllabus of the board. Through the Agricultural Engineering Association, British Agrochemicals Association and the British Crop Protection Council we are continually emphasising the need for training.

Mr Cave Public opinion on the use of herbicides is very much influenced by what they read in the press, and see on television. More could and should be done to educate the media by involving them more closely in scientific and technical discussions. They stand on the outside because they are very rarely invited to the inside, particularly to meetings such as this. I believe that a closer involvement of the press and television, and efforts to educate them would be of great value.

Mr Hanbury We should not overlook the need also to educate resource managers, who, without possession of other information, are also susceptible to the views mostly against the use of chemicals, expressed in the press. There is a great deal of resistance to using herbicides amongst professional colleagues in local authorities and other public bodies.

Mr Price It is stated in the paper that there is no evidence of serious adverse effects upon fisheries from the use of herbicides against submerged weeds, other than occasional deoxygenation problems. I would agree. However, I should like to comment on concern about the possible longterm effects of the regular use of aquatic herbicides on fisheries. A few years ago we (Anglian Water Authority) tried to identify for a study on this problem, some water courses that were both fisheries and subject to regular treatment with aquatic herbicides for the control of submerged weeds. We failed to find any, because chemical control was confined to watercourses that were too small to support resident fish populations. Thus our experience of the use of herbicides to control submerged weeds in fisheries is very limited. We need to be cautious before reaching too firm a conclusion on the safety of their use under river conditions until we have had further experience and can feel totally reassured.

Mr Robson (Speaker) We have actually used herbicides more in small lakes and club fisheries, and there have been occasional problems with deoxygenation, but not any long term effects so far as I know. The advances that are now being made with techniques of partial control of water bodies, and selective control of species using diquat alginate, will overcome the deoxygenation problems to a large extent. But I agree entirely about the concern over river fisheries.

Sir Ralph Verney In the Seventh Report of the Royal Commission on Environmental Pollution on Agriculture, we were particularly concerned about the build up of resistance among pests to all forms of chemical control. Is there any evidence that plant resistance to herbicides is as great a problem as insect resistance to insecticides?

Mr Robson (Speaker) The only group of herbicides to which any resistance has been detected is the triazines, but this is a very minor problem. There is no comparison between resistance to herbicides, and resistance that builds up between insects and insecticides. Nevertheless, we are very much aware of the possibility of resistance to herbicides and are looking out for it, both in Britain, and worldwide.

Dr Way I was very impressed in America with some work that I was shown concerning the management of cleared wayleaves through woodland for electricity power lines, and also firebreaks in forests. Here the development of tall growing vegetation was controlled, not by irregular cutting or by bulldozing, but by the much more ecologically satisfying way of maintaining a dense low cover that prevented establishment of the taller species. This cover was encouraged by the selective removal of taller woody species at a young stage using herbicides. The advantage of this was that there was no damage to the desirable species, no opening up of the canopy of the ground cover, and no disturbance of the soil to encourage invasion and establishment of unwanted species. This seemed to me to be a way in which we could work with nature, even though using chemicals, and not bloodying our noses at great expense by trying to fight against natural processes. There is considerable scope for the selective use of herbicides in this way, and both for research and development to bring them into use.

Research on Ecological Aspects of Vegetation Management

M. D. Hooper
Institute of Terrestrial Ecology

INTRODUCTION

My purpose in this paper is to review briefly some of the recent and current research in the Institute of Terrestrial Ecology (ITE) which has a bearing on vegetation management, and give some indication of possible lines of work for the future. Future research programmes on vegetation management are currently under discussion in ITE. Hence any statement made now must, of necessity, be predictive of a policy for the future. Such a statement may be coloured by personal preference. I would emphasize that the selection of topics for review, their grouping together under headings and possible lines of future development are all my personal choices, though I have tried to take account of what I believe to be my colleagues views.

CLASSIFICATION : LAND CLASSES AND VEGETATION TYPES

Research in ITE covers a very wide range of land classes and vegetation types. There are only two significant boundaries : in general, we do not work below the low tide mark nor do we work on arable land. Hence over two thirds of the surface of the UK (approximately 17 million hectares) falls within our remit, including inland waters (300,000 ha) in the form of lochs, lakes, reservoirs, and rivers.

This large range, which excludes only tillage and ley grassland, can be subdivided in a number of ways to varying levels of detail. At the broadest level I would suggest four classes:

i agricultural lands to include permanent grass and rough grazing (11.4×10^6 ha);
ii urban amenity grasslands including parks, golf courses, and road verges (0.5×10^6 ha);
iii woodlands including productive forest and natural woodlands (2.15×10^6 ha);

iv aquatic situations ranging from open water to marshland. (0.4×10^6 ha).

Each of these classes can be and usually is, further subdivided. Problems arise in that we are often imposing artificial classes on continuous variation. Such problems are well known and are only a minor irritant in that, for example, not all classes are mutually exclusive and areal statistics are therefore difficult to reconcile. Rough grazings (6.4×10^6 ha), for example, could be subdivided as to level above Ordnance datum:

Montane – above 500 m	0.4×10^6 ha
Upland – above 250 m	4.0×10^6 ha
Lowland	2.0×10^6 ha

Many of the lowland types, and some of the upland too, could also be counted as amenity land. Thus, Liddle (*in* NERC, 1977) was able to produce a classification of amenity grasslands with a total area of 0.8×10^6 ha, which contrasts with 0.5×10^6 I have quoted above.

Subdivision, within the classes at this level, has often been attempted without estimates of the relative area. An exception is the work on amenity grass classification which also provides some estimates of costs (NERC, 1977).

Another example, at the next lower level, is the work of Hill & Evans (1978) on Upland Vegetation which groups 17 types into 5 classes:

i Acid grasslands (*Nardus, Molinia, Pteridium* etc.)	42%
ii Heath (*Calluna, Vaccinium*)	29%
iii Bog (*Sphagnum, Eriophorum*)	23%
iv Rush and flush (*Juncus, Carex*)	4%
v Calcareous grasslands (*Festuca, Thymus*)	2%

This type of classification exercise has so often been carried out in ITE that considerable thought has been given to methodology, especially in the context of analysis of data from surveys. This work started at Bangor with surveys of Snowdonia and the Lleyn peninsular, but has spread to Merlewood with the survey of Cumbria (Bunce, 1978).

One outcome of this type of activity is a system of land classification (Bunce, 1981) which has the distinctive merit of being usable as a sampling frame for a stratified sampling programme.

This aspect of the system has been of considerable use to our own work, in surveys of particular types of land (e.g. Railway land, see Sargent, 1981) and in dealing with particular problems (e.g. Foxes and the spread of Rabies, see Bacon & Macdonald, 1981).

As the system can also provide estimates of particular types of land use quickly and efficiently it is now becoming recognised by planners.

OBJECTIVES OF MANAGEMENT

The objectives which ITE has to take into account in its research on vegetation management are also extremely varied. It is possible to generalize the variation to the two words, conservation and control, but this merely disguises the variation.

Under the general heading of a conservation objective we may be seeking to understand the ecology of a food plant of a rare insect in order to manage the plant for the conservation of that insect (Thomas, 1980).

Conversely under the heading of a control objective we could be testing the suggestion that a plant species could be controlled by an herbivorous insect (Dempster & Lakhani, 1979).

More often the objective is both conservation and control: to enhance the performance of desirable species and limit undesirable species at one and the same time. For example, it may be possible to limit a population of grey squirrels by altering the structural elements and component species of productive woodland (Kenward, 1980), or conserve the floristic richness of heathlands by controlling bracken with asulam (Lowday & Marrs, 1980).

ITE'S OBJECTIVES

To an extent the objectives of management *per se* may be outside ITE's objectives for the research itself. The Institute accepts contracts from other organizations or agencies which may have general management objectives and a specific objective in placing the contract for research. But the objective of the research, as seen by the Institute, could be said to be the better understanding of either the original problem for which a management regime is a proposed solution, or the mechanism or process by which that management regime achieves (or fails to achieve) the solutions of the original problem.

A particular example of this is the work on sports turf. Here a primary objective of management treatments such as sowing, mowing, fertilizing and weeding is the enhancement of either wear resistance or the recovery of the turf from wear. Here a research project on the growth and competition between two turf grass species showed the dominant effect of individual plant size on recovery from wear and that plant size was, in turn, dependent upon seed rate (Parr, 1981).

An important corollary of attempting to understand mechanisms or processes rather than particular situations is that the conclusions should have some generality of application. Therefore, although much of the research is organized for day to day management as individual projects, the projects are grouped in programmes. For example, the work on competition in sports turf species is linked with work on upland grass competition (Jones, 1980), and other sports turf work at the Sports Turf Research Institute (e.g. see Gore *et al.* 1980).

Similarly the work on bracken control with asulam is linked with the use of bracken among other species as a biofuel (Callaghan *et al.* 1980) through more basic studies of bracken growth (Chen & Lindley, 1981).

Thus, an objective of ITE's research can be seen to be to contribute to a number of major areas of interest. Fundamental studies such as those on the flowering of terrestrial orchids (Wells, 1981), which are part of autecological research programme, may produce conclusions applicable to grassland conservation. Alternatively, within a programme on the ecophysiology of trees, a project may be set up specifically to manage the tree for breeding purposes (Longman & Edwards, 1977). Even programmes at first sight unrelated to, can produce results of significance for, vegetation management: research on mammalian ecology is a case in point. The work on squirrels has already been mentioned (Kenward, 1980), but there is also work on deer (Staines & Welch, 1978; Staines *et al.* 1980), and rabbit (Davies & Myhill, 1980), as well as work more directly on grazing (Welch, 1977), which can have implications for vegetation management.

ITE'S PROGRAMME

Currently four of ITE's programmes of research are directly concerned with vegetation management: one indeed has that title, another, on 'Forests and Woodlands', has management in its subtitle, while the titles of the third and fourth, 'Rehabilitation of Vegetation on Disturbed Sites' and 'Nutrient Cycling', indicate a clear relevance.

The programme on management as such contains a series of projects, some of which have already been mentioned (Lowday & Marrs, 1980; Welch, 1977; Parr, 1981). In addition to these are a series of projects on coastal situations (Gray *et al.* 1981; Boorman & Fuller, 1977; Gray & Scott, 1978; Ranwell, 1979 etc are typical) and a lesser number with important links with other programmes such as invertebrate ecology (Morris, 1978; Morris & Ward, 1981).

The programme on 'Forests and Woodland' management has been covered recently (Last & Gardiner, 1981), and hence little more need to be said save that it is continuing.

The programme on Rehabilitation of Disturbed Sites deals with the creation of vegetation cover on a variety of difficult sites: coal waste (Wilson, 1979, 1980; Good, 1978), quarries (Davis, 1982) as well as the creation of herb rich swards (Wells *et al.* 1981).

This type of work links with problems of establishment after treatments with chemicals (Lowday & Marrs, 1980) as well as establishment on naturally difficult sites (Miles & Kinnaird, 1979; Chapman & Rose, 1980) and growth in the presence of pollutants (Perkins *et al.* 1979; Pelham, 1981). From this point it is only a small step to a consideration of nutrient chemicals and their cycling in the fourth of the programmes.

This programme covers the occurrence of nutrients in the soil particularly in the uplands (Heal & Perkins, 1978), and the effects of vegetation on soils (Miles, 1978) together with studies of the soil fauna and flora (Satchell & Gilham, 1981) within a framework of nutrient cycling (Hornung, 1981). Hence, it is not difficult to link vegetation management with phosphorus in woodland soils (Harrison, 1981) via the nutrient status of plants (Grimshaw, 1980), and go on to a consideration of the ultimate effects of a plant host's nutrient status upon the performance of a rare butterfly of conservation interest (Warren, 1980; Thomas, 1977).

Other research programmes naturally contribute; I leant very heavily on our own Land Classification programme for data on the types and distribution of vegetation of interest. There is one programme, however, which needs a special emphasis: that on pollution. The Institute covers a wide range of research covering organochlorines, heavy metals and atmospheric pollution. Of these the first two appear to have major impacts on animals and are only locally important as on spoil heaps (Clarke, 1977) for plants. Atmospheric pollution on the other hand does appear to have significant effects on plant growth and must be seen as a constraint upon vegetation management (Nicholson *et al.* 1977; Nicholson, 1981). Naturally vegetation management methods can also be seen as producing pollution problems for animals (Scorgie, 1977).

FURTHER RESEARCH IN ITE

Two methods seem possible for predicting future work in ITE: either to project recent trends forward or to make judgements on the merits of existing research. particularly in respect of gaps in the coverage and desirable changes in emphasis.

For the first method several trends are apparent, but may be more apparent than real. The decline in number of staff at Colney/Norwich from 14 in 1976 to two in 1982 might seem to imply a decline of our interest in coastal vegetation, but there are similar numbers of projects on coastal habitats now as in 1976. More real and possibly of significance for the future is the marked decline in the Nature Conservancy Council's support for commissioned research (Jeffers, 1980), which has led to a distinct reduction in research on wildlife conservation. However the first years of ITE's existence have seen both a rise and fall in support from the Department of the Environment. Hence, it is possible, though I cannot suggest that it is probable, that research on conservation could increase again. In any event, research on conservation is part of the Natural Environment Research Council's (NERC) remit so it is impossible to predict a decline to extinction.

Using the second method, making judgements, is clearly dependent upon personal bias. At the same time the general statements of policy by the Director at the beginning of each Annual Report give some impression of Management's feelings for the research priorities. In these general statements there has

been, for some time, an indication that a number of topics were of high priority. This year the significance of certain topics has been given greater importance by the replacement of the old organization of ITE into Divisions and Subdivisions (Jeffers, 1978), by a new organization based on the stations and on research topics of programmes.

Those programmes which are of direct relevance to vegetation management I have already mentioned. As they have only recently come into being it seems reasonable to suppose that they will continue for some time to come. What is not yet clear is the direction any one is taking. Within the programme on vegetation management itself it is not certain whether a clear theme will emerge, to link all the individual projects. I myself think that this programme as presently constituted has one major gap in its coverage: insufficient importance is given to the water factor, to drainage and irrigation as management tools or to rainfall and soil moisture as ecological factors.

I suspect however that more important in the long term will be the importance of links between programmes. At the moment vegetation management has strong links with soils in upland situations but there is little contact between the work on lowland grasslands and that on lowland soils, possibly because there is little work on lowland soils in ITE.

Another link between programmes which I should like to see developed is that between vegetation management and the animal groups. Some links exist with the mammal work but the links with work on invertebrate ecology are rather tenuous. Ideally, of course, there should be a chain of contact between several boundaries, for example, from consideration of soil nutrient status through plant growth to the performance of the animals feeding on the plant, linking three research programmes.

Finally, there is one other potent force for creating linkages between the programmes and that is the growing need for some unified system of environmental impact analysis, with all that would entail in terms of co-operation, not only between the subdisciplines of ecology, but also between ecologists and others, and with all it would entail in terms of specific methods for land classification, survey and monitoring. These are fields in which ITE is particularly strong. Moreover ITE is a research organisation independent of any particular land use policy or method of land management. It is therefore ideally placed to carry out unbiased assessments of the effects of proposals to manage our natural resources.

REFERENCES

BACON, P. J.; MACDONALD, D. W. (1981) Habitat and the spread of rabies. *Nature, London* 289, 634–635.

BOORMAN, L. A.; FULLER, R. M. (1977) Spread of Rhododendron on sand dunes. *Institute of Terrestrial Ecology, Annual Report for 1976,* 40.

BUNCE, R. G. H. (1978) Ecological Survey of Cumbria. *Institute of Terrestrial Ecology, Annual Report for 1977,* 30.

BUNCE, R. G. H.; BARR, C. J.; WHITTAKER, H. A. (1981) An integrated system of land classification. *Institute of Terrestrial Ecology, Annual Report for 1980,* 28–33.

CALLAGHAN, T. V.; MILLAR, A.; POWELL, D.; LAWSON, G. J. (1980) A conceptual approach to plants as a renewable source of energy. *Institute of Terrestrial Ecology, Annual Report for 1979,* 23–34.

CHAPMAN, S. B.; ROSE, R. J. (1980) The establishment of seedlings on lowland heaths. *Institute of Terrestrial Ecology, Annual Report for 1979,* 86–89.

CHEN, L. Z.; LINDLEY, D. K. (1981) Primary production, decomposition and nutrient cycling in a bracken grassland ecosystem. *Merlewood Research and Development paper No. 80.* Cambridge: Institute of Terrestrial Ecology.

CLARKE, J. M. (1977) Tree selection studies for revegetation of exposed sites and areas of dereliction. *Institute of Terrestrial Ecology, Annual Report for 1976,* 37.

DAVIES, D. T.; MYHILL, D. G. (1980) Rabbit enclosures: a viable scientific approach? *Institute of Terrestrial Ecology, Annual Report for 1979,* 13–18.

DAVIS, B. N. K. (1982) (Ed.) *Ecology of Quarries.* Cambridge: Institute of Terrestrial Ecology.

DEMPSTER, J. P.; LAKHANI, K. H. (1979) A population model for the cinnabar moth and its food plant, ragwort. *Journal of Animal Ecology* 48, 143–163.

GOOD, J. E. G. (1978) Trees for planting industrial spoil. *Institute of Terrestrial Ecology, Annual Report for 1977,* 40.

GORE, A. J. P.; COX, R.; DAVIES, T. M. (1979) Wear tolerance of turf grass species. *Journal of the Sports Turf Research Institute* 55, 45–68.

GRAY, A. J. (1979) The banks of estuaries and their management. In: *Tidal Power and Estuary Management,* 235–244. (Eds. R. T. Severy, D. L. Dineley and E. C. Hawker). Bristol: Scientechnica.

GRAY, A. J.; SCOTT, R. (1978) Grass trials in the wash. *Institute of Terrestrial Ecology, Annual Report for 1977,* 48.

GRAY, A. J.; DURELL, S. E. le V.; BATES, H. E. (1981) Establishing vegetation on unstable coastal cliffs. *Institute of Terrestrial Ecology, Annual Report for 1980,* 97–99.

GRIMSHAW, H. M. (1980) Some aspects of the nutrient status of native British plants. *Institute of Terrestrial Ecology, Annual Report for 1979,* 46–48.

HARRISON, A. F. (1981) Phosphorus in woodland soils. *Institute of Terrestrial Ecology, Annual Report for 1980,* 36–42.

HEAL, O. W.; PERKINS, D. F. (1978) Production ecology of British Moors and montane grasslands. *Institute of Terrestrial Ecology, Annual Report for 1977,* 5–7.

HILL, M. O.; EVANS, D. F. (1978) The vegetation of upland Britain. In: *The future of upland Britain,* 436–447. (Ed. R. B. Tranter). Reading: Centre for Agricultural Studies.

HORNUNG, M. (1981) Geochemical cycling. *Institute of Terrestrial Ecology, Annual Report for 1980,* 102.

JEFFERS, J. N. R. (1979) Research strategy for ITE. *Institute of Terrestrial Ecology, Annual Report for 1978,* 5–11.

JEFFERS, J. N. R. (1980) Summary Report. *Institute of Terrestrial Ecology, Annual Report for 1979,* 5–6.

JONES, H. E. (1980) Experimental observations on competition in grasses. *Merlewood Research and Development paper No. 79.* Cambridge: Institute of Terrestrial Ecology.

KENWARD, R. E. (1980) Grey squirrel foraging. *Institute of Terrestrial Ecology, Annual Report for 1979,* 65.

LAST, F. T.; GARDINER, A. S. (1981) (Eds.) *Forest and Woodland Ecology.* Cambridge: Institute of Terrestrial Ecology.

LONGMAN, K. A.; EDWARDS, M. L. (1977) Making trees flower. *Institute of Terrestrial Ecology, Annual Report for 1976,* 32.

LOWDAY, J. E.; MARRS, R. H. (1980) Bracken and scrub control on lowland heaths. *Institute of Terrestrial Ecology, Annual Report for 1979,* 8.

MILES, J. (1978) The influence of trees on soil properties. *Institute of Terrestrial Ecology, Annual Report for 1977,* 7–11.

MILES, J.; KINNAIRD, J. W. (1979) The establishment and regeneration of birch, juniper and Scots pine in the Scottish Highlands. *Scottish Forestry* 33, 102–119.

MORRIS, M. G. (1978) The effects of management on the fauna of grassland and scrub. *Institute of Terrestrial Ecology, Annual Report for 1977,* 16–18.

MORRIS, M. G. (1981) Recovery of populations of grassland invertebrates from annual mowing. *Institute of Terrestrial Ecology, Annual Report for 1980,* 53–54.

NERC (1977) Amenity Grasslands – the need for research. *Natural Environment Research Council publications Series C No. 19.* Swindon: Natural Environment Research Council.

NICHOLSON, I. A. (1981) Sulphur air pollution. *Institute of Terrestrial Ecology, Annual Report for 1980,* 92–95.

NICHOLSON, I. A.; FOWLER, D.; KINNAIRD, J. W.; PATERSON, I. S. (1977) Fate and effects of airborne sulphur pollutants. *Institute of Terrestrial Ecology, Annual Report for 1976,* 58–59.

PARR, T. W. (1981) A population study of a sports turf system. In: *Proceedings 4th International Turfgrass Research Conference,* 143–150. (Ed. R. W. Sheard). Guelph: Ontario Agricultural College and International Turfgrass Society.

PELHAM, J. (1981) Metal Tolerance in Birch Clones. *Institute of Terrestrial Ecology, Annual Report for 1980,* 99.

PERKINS, D. F.; JONES, V.; NEEP, P. (1979) Pathway of fluoride in a grassland ecosystem. *Institute of Terrestrial Ecology, Annual Report for 1978,* 71–74.

RANWELL, D. S. (1979) Salt marshes and sand dunes. *Institute of Terrestrial Ecology, Annual Report for 1978,* 78.

SARGENT, C. M. (1981) Towards the end of the line? *Institute of Terrestrial Ecology, Annual Report for 1980,* 83–84.

SATCHELL, J. E.; GILHAM, M. (1981) Effects of *Lumbricus rubellus* on moorland soils colonized by birch. *Institute of Terrestrial Ecology, Annual Report for 1980,* 101.

SCORGIE, H. R. A. (1980) Ecological effects of the aquatic herbicide cyanatryn on a drainage channel. *Journal of Applied Ecology* 17, 207–225.

STAINES, B. W.; WELCH, D. (1978) Red Deer Review. *Institute of Terrestrial Ecology, Annual Report for 1977,* 50–51.

STAINES, B. W.; WELCH, D.; CATT, D. C.; SCOTT, D. (1980) Dispersion of Red Deer in a Sitka Spruce plantation and the incidence of bark stripping. *Institute of Terrestrial Ecology, Annual Report for 1979,* 66–67.

THOMAS, J. A. (1977) The ecology of the large blue butterfly. *Institute of Terrestrial Ecology, Annual Report for 1976,* 25–27.

THOMAS, J. A. (1980) The extinction of the large blue and the conservation of the black hairstreak butterflies. *Institute of Terrestrial Ecology, Annual Report for 1979,* 19–23.

WARD, L. K. (1979) Scrub dynamics and management. In: *Ecology and design in amenity land management,* 109–127. (Eds. S. E. Wright and G. P. Buckley). Kent: Wye College.

WARREN, M. (1980) The Ecology of the wood white butterfly. *Institute of Terrestrial Ecology, Annual Report for 1979,* 50.

WELLS, T. C. E. (1981) Population studies of terrestrial orchids. *Institute of Terrestrial Ecology, Annual Report for 1980,* 85–87.

WELLS, T. C. E.; BELL, S. A.; FROST, A. (1981) *Creating attractive grasslands using native plant species.* Shrewsbury: Nature Conservancy Council.
WELCH, D. (1977) Effects of grazing on moorland. *Institute of Terrestrial Ecology, Annual Report for 1976,* 63–64.
WILSON, J. (1979) Tree selection for the revegetation of coal waste. *Institute of Terrestrial Ecology, Annual Report for 1978,* 66.
WILSON, J. (1980) Trees for planting on coal waste. *Institute of Terrestrial Ecology, Annual Report for 1979,* 94–95.

DISCUSSION FOR DR HOOPER

Mr Cobham Your introductory remarks indicated that you regard the role of the research ecologist as essentially one of providing answers to specific questions posed by the client. However, is there not also a role for the research manager to assist the policy and decision makers to understand the problems and therefore the economic choices open to them? Surely the dimension of choice should not be excluded from the research manager's brief, since in many cases the client does not know what questions he should be asking?

Dr Hooper (Speaker) What I should like in an ideal world is for you to come to me and say this is what I think I should like you to do. We should then have a discussion, and before we actually got down to talking about a contract for some work we should get an agreement on our objectives. This should be done together.

Mr Cobham This suggests (since you are addressing me) that the economist should be the client, and should present the research ecologist with a brief. But the economist is not normally the decision-maker, nor the client. His or her role should be complementary to that of the ecologist to help to identify and evaluate resource management options. For example, if research is to be undertaken in the uplands the economist and the ecologist need to work in tandem. Only then is there any real prospect that the cost-effectiveness of the alternative land use and management systems, single or multi-purpose, will be properly evaluated. If a financial consideration is included in the ecologist's brief, even if only by implication, then choice becomes an important consideration. It is only if the ecologist and the economist are put together at the outset, and if jointly they talk to the decision taker, that a sensible research brief is likely to emerge, resulting in the wise use of scarce resources.

Dr Hooper (Speaker) I entirely accept that. What was less acceptable to me was the implication that I had to provide the choices.

Mr Shaw (Chairman) It is by no means very often clear to public agencies what the options open to them are, and an important role of researchers is to help clarify the scope for action.

Mr Peters The time lag between research results and the decision takers being aware of the information, may be as long as ten years. Have we got any ideas on how the results of research can be brought forward more quickly for the decision takers?

In the case of sulphur dioxide pollution in the uplands for instance, scientific knowledge was sufficiently far advanced in the sixties for comment to be made on the death of actively

growing blanket bog in the uplands of the Pennines. Yet the effect of this on the balance of management between sheep and grouse has not been mentioned, even in such a forum as this.

Dr Hooper (Speaker) I agree with you on the general point that there is a responsibility for an ecologist to communicate his research results as widely and quickly as possible, particularly to decision makers. Thus, the Nature Conservancy Council (NCC) has produced a publication intended for decision makers, describing recent Institute of Terrestrial Ecology (ITE) research (done under contract for the NCC) on the 'Creation of Herb Rich Swards', and this has created a lot of interest. The trouble is that most research organisations are not geared up for publicity, or the production of publications intended for the layman. In the past this has been the job of the interpretative, advisory, and executive agencies. However, in the ITE, publications are now being produced for wider audiences and the ITE Annual Report is itself a document that covers the whole range of ITE research.

Dr T W Wright I think that everyone in the forest industry in Britain agrees that the standard of production of the Forestry Commission's bulletins and other publications disseminating the results of research at Alice Holt is quite outstanding, and does a very good job.

Mr Fryer Two years ago I attended a meeting at the National Environmental Research Council (NERC) HQ with a number of others from ITE, Grassland Research Institute and so on, to review research concerned with lowland permanent grassland. It was a most useful meeting, and I had hoped that it would lead to a continuing dialogue, but this has not happened. Has Dr Hooper any ideas on how further discussion and co-operation could be promoted?

Dr Hooper (Speaker) I think the main thing that came out of that meeting was a survey of the research in progress by Dr Joan Moore acting as a private consultant. I anticipate that she has now completed her report, and that this is being considered at NERC HQ.

Mr Carter It has been said that the research worker produces results in response to questions put to him, but he does not provide alternative solutions. The adviser, on the other hand, needs a number of alternatives to present to his client, because the adviser is trained to offer choices wherever possible.

If a change of attitude is being called for amongst farmers, land managers, and their advisers, then this change should also be reflected in the attitudes of agricultural research workers. Managers of agricultural research should now ensure that their research workers relate their work to the wider environment. In the past the preoccupation has been to pursue objectives concerned with increased agricultural production, with the control of pest and diseases, and with other interests related directly to agriculture, but not with the wider effects of the results of their research on the environment.

Dr Green In bridging the gap between the original researcher and the needs of the advisers, or practitioners, there is a requirement for more synoptic, synthetic (as opposed to analytical) research, to bring together seemingly disparate results into an integrated and meaningful whole. Can we rely on the specialists to do this, or do we need specific support for people with wider interests to perform this vital function?

Mr Eadie I do agree that this issue of lack of synthesis is one of the central weaknesses. Part of our research programming in the Hill Farming Research Organisation is concerned with putting the results of our analytical researches together and examining them in whole systems of production. We could, and this has been suggested several times recently, put a wildlife objective into such a hill farming synthesis. The problem is that nobody has come up with a clear set of proposals and objectives, spelt out in terms of a management package, that could be incorporated into our existing programmes. People need to sit down and think hard about actual cases, and until this is done we shall not achieve anything in the practical sense.

Mr. Shaw (Chairman) There are two suggestions here. Firstly for more work to pull together the results of the research that is being done, and secondly to translate that into a practical and readily comprehensible form for use on the farm. The second is at least in part the responsibility of the Research Councils, who by spending a fractional part of their budgets, could ensure that the risk is avoided of the major part being wasted because it is underused, not understood, or used too late in the day.

Mr Waterson Surely the talk here about the synthesis of agricultural research is really the devlopment and interpretative work that is the function of the Agricultural Development and Advisory Service and of the Scottish Colleges Advisory/Development Services. Rather than propose new forms of organisation, we should make use of those that we have already. In Scotland the advisory services have only recently been given formal instructions to take on work on wildlife, arising from the Wildlife and Countryside Act. One of the results of this is that we shall now be actively supporting the formation of Farming and Wildlife Advisory Groups in Scotland.

Concluding Statement

M. W. Holdgate
Department of the
Environment

The general aim of our meeting was to illuminate the management of semi-natural vegetation (Professor Last having reminded us how little strictly natural there is in Britain, and that the more natural it is the less it is likely to be managed).

Speakers were asked to define the classes of land with which they were concerned, the vegetation types, the objectives of management, the past and present methods, the costs of alternatives, the problems and the uncertainties demanding research. We were thus instructed to be severely practical.

Professor Last (and Dr Hooper) discussed how objective systems of classification could be derived by analysing features recorded on topographic and geological maps. Professor Last went on to show how the 32 national habitat types he and Dr Bunce had defined could be used to stratify field surveys of vegetation. Repetitive sampling could equally provide a simple and fairly cheap monitoring of the major changes in the relative extent of woodlands or heather moors, or in the length of hedges. I am not here to make a policy speech for the Department of the Environment, but I would like to say that we in the Department entirely accept the need for such monitoring and are discussing just how to do it with colleagues in the Institute of Terrestrial Ecology and the Nature Conservancy Council. What we must do is ensure that any system is soundly based (even Professor Last's objective habitat types are based on parameters subjectively chosen from maps) – and accepted as valid by all the agencies interested in our changing countryside.

Professor Last made other important points. When selecting sites for wildlife conservation we should sample the representative – the commonplace – as well as communities at the extremes of the range of variation. And we should conserve the genetic range within species.

In managing land – whether for agriculture or conservation or both – we need to understand the life strategies of species and the dynamics of species and communities. We do know a good deal about how upland vegetation responds to grazing, and about how grasslands change as nutrient levels vary

over time. We could perhaps use our knowledge more positively – for example to crop different native species like bracken, for energy, or to generate more beautiful roadside verges (which Professor Last calculated as accounting for 0.5% of our national land area).

Professor Last's theme was thus that of the scientifically imaginative manager. I think we did tend to ambivalent thinking in the subsequent papers although Dr Hooper came back to the point with his questions, "What's where?, Why?, What happens if . . . . ?, Does it matter?". Some equated the management of semi-natural vegetation with management for conservation in the narrow sense of preservation for wildlife: others – for example Mr Steele – took a far wider view.

In analysing the meeting as a whole, three themes impressed me. The first concerned the intrinsic features of the land systems whose management we have been discussing. I was struck by the way the papers by Mr Clegg, Mr Cave, Mr Gilmour, Mr Dunball, Dr Green, Mr Carter and Mr Mercer could in a way be linked by a common theme. It hangs on whether management aims to keep nutrient status poor (or simply has to accept that condition) or whether management is confronted with a nutrient-rich situation.

Dr Green and Mr Christensen especially dealt with situations where management had to keep nutrient levels low to sustain desired features: chalk grassland and lowland heath or species rich hedge bottoms. Dr Green showed that grazing regimes that removed nutrients or burning that vaporized them were appropriate tools, properly managed. He also demonstrated that the botanist, entomologist and ornithologist would seek different land managements, the latter tolerating the most nutrient-rich situation, sustaining scrub. The montane Pennine moors and acidophilous bogs of Dartmoor, described by Lord Peel and Ian Mercer, like the mountain limestone grasslands and the oligotrophic lakes not discussed by anyone, are also areas where nutrient poverty is sought by wildlife and landscape conservationists and grouse moor managers (though fertilisers can actually help grouse numbers on the poorest land if moderately applied), and accepted perforce by most hill farmers. Lord Peel's paper showed how increased stocking density and nutrient-retention by winter foddering by the sheep farmer could undermine the grouse shooting interests and provoke a real clash.

Other papers discussed situations where nutrient poverty might perhaps be worth seeking for convenience as a management tool. Mr Gilmour reminded us that the public could demand a mown sward and threw litter on a neglected one: I wondered whether, if one could get the nutrients down, a heather moor (if it could be managed by cutting and not burning) could be an acceptable substitute in some areas. Mr Robson discussed chemical means of diminishing fertility and retarding growth. Mr Dunball gave reasons why fairly orthodox seeding on restored topsoil attracted him in preference to attempting natural re-seeding on subsoil, but I detected a mood in part of the audience of wanting to debate the prospects for low-nutrient systems further. At least, Mr Dunball made it clear he sought minimal management systems, only keeping road verges

clear of impediments to visibility and drainage and accepting successional change so long as one did not come to drive from Birnam to Dunsinane in one gloomy tunnel of trees.

Then there are nutrient-poor systems we accept because it doesn't pay to convert them to higher status. Much upland heath, moor, bog and coarse, pasture is in this state. Some, notably Mr Mercer's moorland fringe, oscillates between management only by stocking density (often insufficient to prevent woodland growth) and intensive reclamation, as economic circumstances vary. We saw how some of Lord Peel's moors, like others on Exmoor, teeter on the brink of this change and are hence susceptible to being switched from *Calluna* to grasses inadvertently by stock: some of us would take a bet that we could move a lot of heather moor across to grass by deliberate grazing management.

However, the vast majority of these nutrient-poor semi-natural lands are likely to stay semi-natural without vast defensive efforts by the wildlife conservationist (though Derek Barker and I, in discussion, both teased the meeting by asking whether they should). In contrast we have three groups of nutrient-rich situations.

The first sub-set is one where semi-natural vegetation is retained because it is the most suitable: as on road and rail verges where more productive use is incompatible with the overriding demands of transport.

The second is where agricultural or forest return from the unaltered system is adequate and the costs of conversion are prohibitive. This may be the case (or used to be) with lowland river meadows, game spinneys and much broad-leafed woodland. Such land, like moorland fringe but more so, is however vulnerable to conversion at any time when drainage schemes arrive or economic pressures increase. I suppose Mr Carter's hedgerows fit here also – cherished where they have a job to do in a reasonably cost-effective way but at risk when the balance sheet tilts.

Finally there is land whose current semi-natural state flies in the face of all the economic factors described by Mr Clegg. I place here most adequately drained lowland grasslands, some heath over potentially fertile soils (as in the New Forest) and some of Mr Carter's hedgerows and much scrubland, broad-leafed woodland and (though again omitted from our conference) reclaimable saltmarsh. Such systems will remain – as Mr Christensen and Mr Clegg implied in different ways – as long as the owner wants them to remain (and can afford the opportunity cost) or as long as a management agreement provides an acceptable way of balancing otherwise unbalanceable books.

At an extreme in this spectrum we could place the freshwater systems described by Mr Cave and Mr Robson, potentially highly productive, nutrient-rich ecosystems which we have as yet found no way of cropping in a fashion compatible with the primary requirement of land drainage and where management, whether mechanical or chemical, is designed to get rid of the production. In a sense these are a resource wasted.

That, of course, is only one way to cut the cake. As I said, I discerned two other cross-cutting themes in the meeting.

The second was public attitude – or rather the attitudes of different groups of people. Mr Small brought this out in his demonstration that the various land uses in the New Forest, presumably potentially interchangeable over large areas, were what they were because of human rights and demands entrenched and varied over the centuries and still changing. The public quest for tidiness, as in Mr Gilmour's urban fringe, came out in the antipathy Mr Small reported to woods that had been left to become more natural, reminding me how surprised I was myself when I first walked in a truly natural temperate zone forest in Southern Chile and saw the tangle of decayed, broken and thriving trees.

Mr Steele also reminded us that to make optimal use of a national resource like broadleafed woodland it is inevitable that we shall use different parts of it differently, according to its potential and to the interests of its owners (the vast majority of whom, we were reminded, are individual fellow citizens with rights that must be respected), as well as to the interests of those who may be grouped as "ologists" and "ationists". So we arrived at the end of our second day where Mr Clegg had started us, with a clear message that the management policy for any parcel of land had to be judged individually, blending the intrinsic features of the land with the interests (and the value judgements) of those people entitled to express a view about it. And this led us to stress, as is almost ritual at these meetings, the crucial role of communication and mutual understanding. The fact is that many people do not have an idea what conservation (for example) is. They cannot be blamed. We professionals use the term ambiguously. I use it in the sense of the World Conservation Strategy to mean the wise use of renewable natural resources for human benefit. One wise use can be the protection of nature to perpetuate the balance of biogeochemical cycles, genetic strains, scientific research or the simple wonder, beauty and rich diversity of nature without which (as Wordsworth *alias* Mercer reminded us) the world would be a poorer place.

Understanding must depend on clarity and communication. We are all responsible for ensuring that our ideas are clearly stated and that they are put across in the right language, to the proper recipient. We cannot depend on a busy farmer reading the *Journal of Applied Ecology* and we have some responsibility to try to get our knowledge across to the media, difficult though that is. If we try we may succeed. If we simply moan, we have zero probability of success. And education is linked to communication. The fact is that the real world is managed by people I have elsewhere called "the operators", the practical people, especially farmers and their staff as Mr Christensen stressed, who interact with the land. It is not managed by scientists, economists, civil servants or politicians. New scientific insights have to be got across through interpretation in language of brevity and clarity. We can communicate through the people who advise the operators, like the Agricultural Development and Advisory Service, through the specialist media the operators use, through peer groups like farming clubs or through their own training course (as at Wye College). This information has also to be PRACTICAL, in terms of management

methods for hedge cutting, spraying, spinney or field edge management for game and so forth. It did occur to me to ask whether The British Crop Protection Council should produce not another symposium volume but a practical handbook on semi-natural vegetation management!

My last theme is uncertainty. I will not elaborate it. Time and again in the 48h of the meeting we challenged the adequacy of our data. Professor Last's estimates of areas of land in major categories were challenged by Mr Dunball and Mr Cobham. Mr Cobham's estimates of management costs were assailed from the floor. We agreed we did not know how to monitor change. We are ignorant of the dynamics of environmental systems. We may build mathematical models of ecosystems but they must cater for variables we are still forced to treat as random: as a foremost ecosystem modeller puts it – we must "expect the unexpected".

Where then do we go from here. I suggest we have six recommendations to make:

1. We need a system for monitoring the changes in the major features of our rural scene in a way that will serve the interests of all concerned.
2. We need to understand the dynamics of species and communities better, and their response to management.
3. We need vastly better economic data: Mr Cobham's paper was an eye opener to our ignorance, and we must, as he says, get a much clearer picture of how we are using our management resources and satisfy ourselves that we can use new resources effectively.
4. We need new, practical, management tools with clear understanding of their use. When should burning be used? What grazing systems suit what vegetation types? What are the proper circumstances in which to use growth retardants or herbicides, on land or water? (Mr Robson's paper gives some very pertinent guidance which should surely be followed up).
5. It is axiomatic that we need more research. Every coven of scientists says so. But please let us stress that we need more RELEVANT research, on characterising the resources we have been concerned with, on understanding their dynamics, and on practical techniques for manipulation to ensure conservation in the true sense of the word. Here we should also ensure, as Dr Hooper and others said, that the different research organisations and programmes are truly mutually reinforcing.
6. Finally, we need much better communication with the public and with operators on the ground, through their advisers and through training programmes and peer groups. There is no point in doing research, or in holding conferences, if the wise words do not lead to wiser actions.